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DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT—INDEPENDENT AGENCIES APPROPRIATIONS FOR 1987

HEARINGS

BEFORE A

SUBCOMMITTEE OF THE

COMMITTEE ON APPROPRIATIONS

HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

SECOND SESSION

SUBCOMMITTEE ON HUD—INDEPENDENT AGENCIES

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PART 7

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT—INDEPENDENT AGENCIES APPROPRIATIONS FOR 1987

TUESDAY, MAY 13, 1986.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WITNESSES

JAMES C. FLETCHER, ADMINISTRATOR
WILLIAM R. GRAHAM, DEPUTY ADMINISTRATOR
PHILIP CULBERTSON, GENERAL MANAGER
C. THOMAS NEWMAN, COMPTROLLER
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RICHARD J.H. BARNES, DIRECTOR OF INTERNATIONAL AFFAIRS

OPENING REMARKS

Mr. BOLAND. The Committee will come to order.

We are delighted to have with us today Dr. James Fletcher, the Administrator for NASA who was sworn in yesterday by the President and comes back to this Agency, having served as Administrator from 1971 through 1977.

We want to welcome you, Dr. Fletcher. We think that you are a brave man, and that you will be called upon to make some very difficult decisions in the days and the weeks and the months ahead. Whatever this Committee can do to make that job a little easier, why, we certainly would want to help you out.

You arrive at a time when I think all would agree that NASA is at the crossroads, and over the years this Committee has had considerable experience with NASA, even before NASA, with NACA. In a sense, some of us have grown up with this agency, and we have been with it longer than a lot of those who are sitting in this room who are members of the NASA organization.

We are concerned with the direction in which NASA is headed. We are concerned about some of the problems with which NASA has been afflicted. If someone had asked me a year ago if we would be sitting here today in this kind of atmosphere and this kind of climate, I would have said, no. We would just have routine examination of the justifications of what NASA is asking for fiscal year 1987.

HISTORY OF NASA

But because of what has happened, because of the tragic accident of early this year, and because some of the questions that have been raised by the communications media, by the print media, and the wire and the television, and because some of the questions that are being raised by the public, generally, and will be and have been raised all over this Hill, it is, I think, significant and necessary that this Committee get into some of the history of NASA, some of the decisions that were made in the past, to determine whether or not there was an erosion of management during some of the years that NASA has been in existence.

I want to begin by telling you that, incidentally, we understand that because you have just "arrived here" yesterday that you would not be familiar with all the budget questions that would be asked. So, any of the staff that can answer these questions that we will get into, feel free to have them answer. We will probably get into some of the budget questions this afternoon or sometime next week.

I thought that I would open with a statement and some questions and then turn it over to the Members who are here.

Let me begin with telling you how I feel about what has been happening to this agency over the past months. And I hope in doing so that I can strike the right balance between what I feel are some of the serious problems affecting NASA and at the same time to strike a very positive note.

As I have said, if I had to predict a year ago what was going to happen to this agency in the past 12 months, I would not have even been close to what that prediction might have been. It is hard to imagine how many things could go wrong in such a short period of time.

All last year, both this Committee and I fought a long, hard battle to keep the Air Force on board the shuttle. We also fought to keep the price of the shuttle competitive with Ariane, and we fought to keep NASA's budget at a sufficiently robust level to ensure the viability of this nation's civilian space program.

NASA TRAGEDIES

Last November, we had met with some success on all those fronts, but within a few months things seemed to go awry.

Jim Beggs, who I believe was one of the most capable people in this Government, resigned; Gramm-Rudman stripped $330 million from a $7.656 billion enactment of the NASA budget that we had appropriated for NASA; and, of course, on January 28 we lost seven brave Americans in an accident that many of us had begun to believe could never happen.

But that was not the end. In a sense, the accident has forever changed the character and nature of this agency. NASA's long romance with the American public and the press has forever been changed since the events of that fateful day in January.

In the past two or three weeks, we have had more bad news. Just 10 days ago, NASA's launch of a weather satellite on a Delta rocket ended in failure, and the Air Force Titan 34-D carrying a national security payload exploded on launch. And the press, which I spoke about a minute ago, detailed a long series of waste and misuse of NASA funds over many years.

Let me say on the last point that we will be getting into that, but the Committee ultimately needs to know what in those stories is wrong and what is right, and what has to be done to fix those problems.

We cannot do that ourselves. So, I will direct the Surveys and Investigations staff to review all of the NASA IG and GAO reports and give us a capable view on what, in their view, are the serious problems and how we ought to go about fixing them.

There are a great number of charges laid out in the *New York Times* stories. Many of them were disturbing to me and perhaps shocking to a lot of those in NASA. Many of them, I am sure in your view, were very unfair, and I know that you have supplied answers to them, but not detailed answers.

I also know that I have spent the best part of the past 20 to 25 years telling people in this town, telling my colleagues on the Floor, telling organizations in luncheons and in dinners, telling many who didn't believe in the space program, that with NASA we got the most "bang for the buck." For every dollar invested we got more than a dollar back. I really believe that. When I read those articles in the *New York Times* it caused this Committee and me some concern.

In looking at what went wrong, maybe we were part of the problem. But I believe anyone who honestly looks at the record of the past 12 to 15 years would have to admit that this Subcommittee has been the most critical, the most questioning, and the most skeptical about what NASA comes up here and justifies to us every year.

Of all the Subcommittees on the Hill dealing with NASA, I believe it is fair to say that this Subcommittee has made recommendations that we believe were right, but that always didn't fit with what NASA wanted to do.

But when we hear of engineers whose concerns were either ignored or rejected or not surfaced at the proper levels of NASA, when we hear of astronauts telling us of safety concerns not being addressed, that O-ring problems were not brought to the astronauts' attention, and so on, we cannot help but be concerned.

So we hear these kinds of things, some of which may be overstated, but some of which may not be, it sounds like something is out of kilter.

I am not sure what it is. But I suspect that there is a kind of attitude that no matter what the question, the answer is often, "That is something we are looking at," or "that we don't think there is any problem." We got that answer many times in the history of this Committee.

For me, one of the most recent examples of that kind of attitude that struck me as being surprising was that less than a month after the shuttle accident, five senior officials from NASA held a press conference at the Marshall Space Flight Center and indicated, virtually to the man, that if they had to do it all over again, they would have done everything the same way.

They saw no problem with the system. They saw no problem with the information about the cold weather, the O-rings, etc., etc., withheld from higher levels. Basically, they saw no problem at all.

That is the kind of attitude I am talking about. I think that needs to be addressed, Dr. Fletcher. And I think you will address them, and the organization will address them.

I feel that something has gone terribly awry—and those questions have to be answered and the problems have to be fixed.

We have also heard a great deal in the past few weeks about Congressional oversight and having the Congress perform its oversight role. As I said earlier, I think this Subcommittee has done a reasonably credible job. At least in looking over the hearing records, we have asked some of the right questions. But one thing I do believe is that Congress can't, and this Committee can't, be responsible, because NASA is overcharged on many items. We don't have the resources to do that kind of tracking, and we shouldn't track it. We don't want to micromanage NASA.

In fact, we shouldn't manage the agency at all. I know that we have been accused sometimes of micromanagement. And maybe justifiably. What we have done, and what we will continue to do, is to tell you when we think that you are making a mistake. And when we feel that way or we feel that a problem needs adjustment, we are going to make those recommendations.

But we do have to be responsible to the taxpayers who pick the tab up for this agency. While we can't manage the agency and while we can't track every subcontractor who maybe is falsifying a report, we do have a responsibility to ensure that the management of NASA is on top of these problems and really is getting the most out of every dollar that is appropriated.

So what we can do is this. Until we feel that NASA's management and NASA's house is in order, and until we feel that you have turned this agency around, this Subcommittee can withhold funds for new programs.

Of course, that approach is kind of like throwing the baby out with the bath water. We don't want to do that, and I don't think we will have to do that. But I hope everybody here understands that we are concerned and we believe that some things must be fixed.

SALESMANSHIP IS NECESSARY

Now having said all that, let me say one other thing. I recognize—and I think I am astute enough to realize—that if NASA stopped working on a program every time the GAO cried foul, or every time the IG turned up a problem or every time someone blew a whistle—if NASA stopped working when something like that happened, this country would never fly anything in space.

I recognize that NASA has come up here to sell some of these programs with the attitude of, "look, the Space Station is going to be the greatest thing since sliced bread; it will solve all the problems that we ever had in space, and it will generate billions and billions of dollars of revenue." I recognize that some of that salesmanship is necessary, because if you didn't believe in it yourselves it would be hard to get us to believe in it.

That salesmanship was just as necessary with the shuttle. Now, maybe you oversold it. Maybe some of those projections that were made ten years ago were a pipe dream, but even if that is true, I still believe that the space shuttle is a great asset.

Frankly, I still think it is one of this country's proudest achievements. It is truly a technological miracle, and as the President said in Houston, it is a miracle every time it flies.

NASA has much to be proud of. We have landed on Mars and sampled the soil. We have sent back incredible pictures of that planet and of Jupiter, Saturn, Uranus, and the moons of those planets. We launched 56 manned missions without an accident, and 16 years ago NASA made it possible for this country to be the first to explore the moon. No one has returned to the moon since we last left.

We can't always be guided by those who say, "We can't do this because—" because if that was our position, we would never do anything.

But, my friends, again, this agency is at a crossroads and we need to work together to help fix the problems. If we do that, we truly must work together, not as adversaries, but as partners, and as partners who listen to what each other has to offer.

And I know we are going to come out of these problems with a better space program.

Thank you, Mr. Administrator, for listening to a long—not lecture, but just a little bit of philosophical words.

Thank you for bearing with me during that long statement.

Now we would like to hear from you.

INTRODUCTION OF NEW STAFF

Dr. **FLETCHER.** Mr. Chairman, I must say before I begin that it is really a pleasure to be back meeting with you again in spite of all the problems that we know lie ahead for us.

Before starting, I think I ought to introduce some of the members of our team that are probably new or, at least have new responsibilities since NASA was here last.

We have Bill Graham, who has been appointed Deputy Administrator since we visited with you last. We have Phil Culbertson, now General Manager of the agency. We have Jack O'Brien, the new Chief Counsel.

At the table we have Admiral Dick Truly, who is the newly appointed Associate Administrator for Space Flight. And we have Dr. Ray Colladay, on the end, Associate Administrator for Aeronautics and Space Technology; Mr. John Hodge, Acting Associate Administrator for Space Station.

All of these people have new titles since we were here last and they and the people in the first row are going to help me with some of your questions.

COMMENTS ON OPENING REMARKS

Mr. **Boland**. We are delighted to have all of them, Dr. Fletcher.

Dr. **Fletcher**. Mr. Chairman, one thing in your remarks that you said I want to comment on, because it is absolutely true. This has been perhaps the toughest oversight committee that we have faced in the years that I was here and since then. On the other hand, you have always been fair, and we have recognized that fairness and tried to respond to your suggestions even when we didn't like them. And it turns out in a fair number of the cases, maybe all, you were right and we were wrong.

Having said that, I also want to thank you for the positive remarks that you have made about the past accomplishments of NASA, before moving on to the real purpose of this meeting which is, of course, to address the fiscal 1987 budget request.

If you would permit me, Mr. Chairman, I would like to address some of the detailed concerns which you have mentioned and which we are concerned about, also.

If you allow me to do that first before we go on to the budget, I would appreciate it.

Mr. **Boland**. That is fine.

MANAGEMENT AT NASA

Dr. **Fletcher**. I will submit my formal statement for the record if that is all right and move on to the detailed comments.

First of all, let's talk about some of the concerns. We really have been given the impression that while we all read the newspapers and hear what other people have said, that NASA has always been a poorly managed agency. I am sure that you agree with me that that simply isn't true. We have both watched NASA over the years, you much longer than I. I was the Administrator for six years. Since that time, I have followed rather closely NASA's work and its various accomplishments and the excitement I think, that you have shared with us on some of the things that were done.

I certainly don't condone all of the many mistakes that led to the accident, and I certainly recognize that changes will have to be made.

Mr. Chairman, I also know that NASA has done and is doing a great many crucially important programs. We have fabulous facilities which you have allowed us to build over the years, and we have built up a talented, dedicated team, and I think with a little time and a few changes and the support of this group, particularly, NASA can and will return to some of the greatness that has marked NASA as one of the outstanding entities of the nation.

Mr. Chairman, if I didn't believe that I simply wouldn't have responded positively to the President's request to return.

It is not the kind of thing I would have chosen to do. But I believe it can be done.

Having said this, however, it now seems to be a good time to take a very hard look at the way NASA manages its programs.

PHILLIPS COMMITTEE

We are not completely official on a new program that I am about to announce. I have set up a group under General Sam Phillips, whom you may remember as the Apollo program manager in the heyday of the Apollo program, to take a look at the entire agency. The group will look at how NASA manages its programs with an eye to improving these management techniques, to improving the personnel, improving the relationship between centers and between centers and Headquarters management and to make recommendations to me on how to improve.

We expect this review will take something like six to eight months, at least to the end of the calendar year. It is going to be done in depth.

Unfortunately, we don't have the members of General Phillips's Committee and we don't have a statement describing his duties, but we hope to have that before you shortly.

I think that needs to be done if for no other reason than it hasn't been done lately and should be done.

I think, however, we have the time to do it in view of the standdown of the flight program, and we will do that along with looking at the management of the new programs like the Space Station.

TREATMENT OF NASA BY THE MEDIA

I, too, am very appalled and disappointed about the way the press has treated NASA recently.

They seem to have forgotten all of the creative accomplishments that the U.S. space program has made over the last 25 years or so, and they seem to want to focus on all the mistakes and a few problems that the agency has had recently.

In particular, I would like to comment on the media articles that dealt with the supposed mismanagement, particularly the *New York Times* article that you referred to.

ROLE OF THE INSPECTOR GENERAL

Let me say right off that the Inspector General (IG), which does compile a large number of reports, and the General Accounting Office (GAO), which also before that compiled a large number of reports about NASA and other agencies, are a fine group of people, and we regard them as an integral part of the way we manage our programs. Many of the things that the IG comes up with are brought to the IG's attention by our own internal audit system. So, we have the highest regard for these agencies and we regard that as an important adjunct, much the same as a business would do with their own internal audit or their external audit. This is a normal function of the way we do business.

Having said that, if you only look at the audit reports and don't look at our response to the reports, you get a rather distorted picture of what NASA really is. Sure, we have made a lot of errors, and we have corrected them as a result of the various audit reports sent to us.

I don't know what the percentage is, but our intuitive guess is over 90 percent of them were responded to favorably, and we went ahead and fixed the problems.

We hope it will be 99 percent in the future.

We are also trying to improve the way we manage our programs.

So, the main point is that, yes, we do regard those as important functions; yes, we do hope to be able to do better in the future. But in just looking at that part of the program, you do get a distorted picture of how well we manage things.

NASA'S SUCCESSES

Moving on, I would like to, again, as you have done, remind us all that this is the same agency that placed 12 men on the moon, landed them safely and brought them back.

We have sent spacecraft to the outer reaches of the solar system. Some of them are still operating. We have explored the sun in some depth, which is the source of life here on Earth, and we have explored the universe with telescopes, observatories of all kinds.

We have looked at the Earth from space and looked at the Earth's resources and how they change. We have developed weather satellites that have allowed us to give longer forecasts, pretty reliable, out to three or four days, which never was able to be done before, and, as you undoubtedly know, revolutionized the long-range communications in this country.

We have developed a space shuttle, as you mentioned, and it has done absolutely incredible things in the 24 flights that have gone on so far.

I have observed most of this from a distance, reading in the paper, but it is almost a dream come true. They have actually repaired satellites, two of them, I think. They have retrieved satellites. They have launched 25 or so communications satellites.

They have done good science in the Spacelab. It is almost as though the dream that we talked about in the early days, Mr. Chairman, came true.

It is hard to believe that some of the media articles that were written about NASA is the same agency that we talked about a year ago. It is the same group, but we have made some mistakes. And we have had problems. This last one, in January, was certainly the biggest problem we have had. But we have had other problems in the past. We are an R&D agency, and if we didn't have problems we wouldn't be doing the right job. Having said that, I don't want to have another problem like the one we had in January. We are going to take special care not to have that happen again.

OVERVIEW OF NASA'S FY 1987 BUDGET REQUEST

Moving on, I would like to discuss some of the overall aspects of the budget that is before you.

The President's budget, as you know, was made before the accident, and there are some modifications that will be required to that budget.

One thing is absolutely clear to me, and that is that we can't go on and fix the problem with the shuttle and again order a replacement orbiter without a supplemental of some kind.

We are not here before you with that supplemental. That is a missing piece of the budget.

It is my understanding that we will be able to give you a rough cut which will hold up in its overall aspects. The overall amount will not change appreciably, although the details may change as a result of things that are going to happen in the next two or three weeks.

We hope to be able to work with the White House quickly and get that supplemental to you. Unfortunately, we are not there with it now.

After all, it has only been one day since I have been on board, and that is my highest priority at the moment.

One other thing I think we have been able to firm up on which we are reporting to you, perhaps for the first time, although it has been rumored in the press, and that is the start date for when we fly again.

We think now that July of 1987 is an appropriate flight date which is reasonably safe, as safe as we can make it, and we will begin to accommodate the various missions that are scheduled for it.

This may change depending on a number of factors, particularly those that might come out of the Rogers Commission report which we don't have yet.

But we felt we ought to go ahead and plan the best we can. Admiral Truly may have more to say about that later. But nevertheless, July 1987 looks like a good target date.

DETAILED MANIFEST

We have, unfortunately, another missing element today which we expect to clear up shortly, and that is the detailed manifest for those first few shuttle flights. Those are critically important, because it involves not only priorities between science, military and internal missions, but it involves scheduling of things like the Centaur and planetary missions. Safety has to be interleafed with possible schedule slips and priorities.

That has been done rather well by Admiral Truly, and if there is any blame for the manifest not having come forward today, it has to rest on my shoulders because I felt I needed to take a look at it with him before firming up on our appropriate manifest for the first year. Admiral Truly may want to have more to say about that later. Having said that, there are these two missing pieces: we don't have the supplemental and we don't have the detailed manifest.

I think you will find that we are agreed that the overall cost of our programs, assuming the supplemental is reasonable, will not change very much.

There may be some details in the various pieces of the budget which will change, but I hope not very much, depending on that manifest, particularly.

We will come back to you, of course, with those changes as soon as we firm up on those two missing pieces.

In summary, I apologize about not being complete this morning. I also apologize, and I accept your understanding, for not being completely up to date.

I will try to answer as many of the questions as I am able to, but I will have to rely very much on members of my staff.

Mr. **Boland**. Thank you.

[The statement of James C. Fletcher follows:]

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PRESENTED BY WITNESS

Statement of

Dr. James C. Fletcher
Administrator

National Aeronautics and Space Administration

before the

Subcommittee on HUD-Independent Agencies
Committee on Appropriations
House of Representatives

Mr. Chairman and distinguished Members of the Subcommittee:

I am very pleased to have the opportunity to appear before the Subcommittee and represent the National Aeronautics and Space Administration for a second time. A great many things have happened to NASA in the nine years since I last appeared before you as the Administrator. Most of it has been good, like the Voyager discoveries as they toured the outer planets; the initiation of shuttle flights; and the 24 successful shuttle flights which truly demonstrated that regular access to space is practical with a reuseable vehicle. On these 24 flights we have conducted numerous materials processing and life sciences experiments which demonstrate the commercial potential of space; photographed and mapped large portions of the Earth's land mass and seas with new visual and radar systems; successfully launched twenty five communications satellites; repaired the Solar Maximum Mission and the Syncom Satellites while in orbit; retrieved two inoperative communications satellites and returned them to Earth for repair; and have demonstrated that large structures can be deployed and assembled from the shuttle. Also I am pleased to note the forward looking new starts of the Space Station and the Aerospace Plane. Unfortunately, judging from the negative criticism NASA is receiving in the press, people seem to have forgotten these spectacular achievements and choose to focus on the tragic misfortunes which have befallen the Nation's space program. I firmly believe that the NASA enterprise is vital to the future of our great Nation and I am confident in the ability of NASA to recover from the accident, otherwise I would not have agreed to be here today as Administrator. Mr. Chairman I look forward to your assistance and guidance in returning the National Aeronautics and Space Administration and America's civilian space program to the forefront of leadership in space exploration.

I am here today to present President Reagan's FY 1987 budget request for NASA which was transmitted to the Congress on February 5, 1986, and to discuss revisions which we think will be necessary as a result of the Challenger accident. The pending NASA FY 1987 request is for $7.7 billion, of which $3.0 billion is for Research and Development, $3.1 billion for Space Flight, Control and Data Communications, $181 million for Construction of Facilities, and $1.4 billion for Research and Program Management.

The loss of the Challenger obviously will affect many aspects of the budget request before you, but you may be assured that a majority of the program presented in the President's budget remains valid and we are prepared to discuss the impacts of the accident on the program.

The United States remains committed to the development of a permanently manned Space Station, and the budget request before you reflects this commitment. Recognizing that the Space Station is essential to ensuring American leadership in space during the 1990's and beyond, President Reagan has continued to reaffirm his support, most recently in his 1986 State of the Union address. In the decades ahead, the Space Station--still our next logical step--will enable us to continue the exploration and utilization of space, an enterprise in which the United States traditionally has excelled. The Space Station will represent a new level of capability in space, it will be a permanently manned facility for science, commerce and technology.

The FY 1987 budget request initiates Space Station detailed design and hardware development. This follows a three-year period of extensive work in Space Station definition and preliminary design, which has provided a sound review of Space Station systems, and a thorough understanding of overall Space Station architecture. From the analysis so far, a Space Station baseline configuration has emerged that balances user requirements, technical factors, cost considerations, and an assembly sequence that accommodates the man-tended approach this Subcommittee directed us to develop in 1984.

Initiating development of the Space Station in FY 1987 is extremely important. It will signal to our international partners that the U.S. commitment to the Space Station is firm and that their own budgetary and intellectual resources can safely and productively be devoted to a cooperative Space Station Program. It will signal the private sector here in the United States that future investments in commercial space activities can be planned with confidence. It will signal to U.S. industry that the Space Station Program is on track and that its own investment of money and talent is justified. In addition, moving forward as planned will signal the Soviets, who now have an operational Space Station, that their current advantage will not remain unchallenged. Perhaps most importantly, proceeding with Space Station development in FY 1987 strengthens the commitment to U.S. leadership in space in the 1990's and beyond and signals America's intention to look confidently to the future.

A major feature in the science and applications portion of the FY 1987 budget request is the initiation of the Topex flight program. This ocean topography experiment, which is being conducted in conjunction with France, will provide information leading to an understanding of the world's oceans far exceeding anything known in the past. The fact that 85 percent of the Earth is covered by oceans and that much of this area is far from normal shipping lanes or aircraft overflights has prevented the ocean science community from effectively addressing the question of ocean circulation on a global basis. We anticipate that Topex will result in a greatly expanded understanding of how our ocean systems work. This will be of great benefit to both the ocean science community and to users of ocean data such as shippers, fisherman, and others dependent on the ocean as a source of resources or income.

A series of already-approved space science and applications flight projects are progressing toward flight readiness. While the launch dates of these projects are obviously delayed by the Challenger accident, their objectives and their importance to the expansion of human knowledge remain unaffected. When we resume space shuttle flights, the Hubble Space Telescope, which will provide a quantum jump in our ability to observe the universe; Galileo, which will probe the giant planet Jupiter; and Ulysses, the ESA-developed mission to probe the polar areas of our Sun, will be ready for launch. Other space science and applications missions included in this budget are the Gamma-Ray Observatory; Magellan, a mission to map the planet Venus; the Mars Observer; the Upper Atmospheric Research Satellite; and the scatterometer sensor for the Navy's Remote Ocean Sensing System (N-ROSS). In the field of solar terrestrial physics, we are proposing a program which will allow us to participate as experimenters in a comprehensive international research program.

The budget includes a continuing substantial and very productive program of research and analysis in areas ranging from physics and astronomy, to life sciences, to geodynamics, to upper atmospheric research and many other areas. The most striking product of this program in recent months has been the highly successful and exciting Voyager spacecraft encounter with the planet Uranus. Some of the important new findings include fundamental scientific discoveries about the planet Uranus and its rotation, magnetic field, atmospheric structure, rings and satellites. Observations of the innermost moon, Miranda, show perhaps the geologically most unique moon yet encountered in the solar system.

The budget request also provides for the important continued investment in advanced space technology. In the space research and technology program, increased emphasis is planned for automation and robotics research to enhance the productive and effective use of space and on transportation technology for low cost access to and from space and between orbits.

In his State of the Union address to Congress this year the President referred to research underway on a joint NASA/DOD National Aerospace Plane Program. The aerospace plane is a vehicle, part aircraft, part spacecraft, which could fly from the Earth through the atmosphere into space and back. A significant initiative in the NASA budget involves focused research on this aerospace plane technology and is a direct outgrowth of advances and breakthroughs during the past decade in NASA's ongoing aeronautics and space research and technology base programs. The critical elements of the program will include airbreathing propulsion systems that can operate from take off to near orbital speeds, reusable efficient thermal structures, and integration of the propulsion system and airframe for a minimum weight system with good performance throughout a broad range of acceleration, cruise, and maneuvering flight conditions. Advances in many of these technologies will be applicable to both airbreathing and rocket powered vehicles, thereby further increasing the potential payoff to all future space transportation systems. The technology development in this next phase of the program will provide the basis for a future decision to proceed with the experimental vehicle phase of the program.

During this past year, the White House Office of Science and Technology Policy announced the establishment of National Aeronautical R&D Goals designed to focus U.S. research and development in high pay-off technology areas that will sustain the Nation's aeronautical preeminence into the 21st Century. Our program of aeronautics research and technology is proceeding to meet these goals by providing the cutting-edge technology for future aircraft. As an example, the advanced turboprop propulsion system, which is receiving increasing industry attention and support, will go to flight early in FY 1987 and may soon lead to a whole new generation of fuel efficient transports. Later this year the Numerical Aerodynamic Simulation (NAS) capability will reach operational status. NAS will be the most powerful computing system in the world and a national resource for computational solutions to complex fluid flow and structural problems encountered in advanced vehicle concepts.

Now let me turn to the impact of the Challenger accident on our funding plans for FY 1986 and FY 1987. In brief, these impacts include:

- o reduction in near-term funding requirements for planned flight activities, for payload and mission preparation and related supporting activities. The net reduction in NASA funding for shuttle operations reflects savings in operational costs partially offset by loss of expected reimbursements from foreign and commercial users of shuttle;

- o redirection of some effort previously planned for operation of major missions such as Space Telescope and Galileo into sustaining activities in preparation for revised mission activities when shuttle flight operations are resumed;

- procurement of a Tracking and Data Relay Satellite (TDRS) spacecraft to replace the TDRS which was destroyed;
- continued operation of tracking ground stations which had been planned for closing;
- delayed the planned main propulsion system ground test pending further examination of the technical issues involved in that testing;
- accident investigation requirements, including salvage operations; and
- undertake corrective actions, identified by the Rogers Commission and our own investigations, such as on the solid rocket boosters. The solid rocket motor field joints will need to be redesigned, hardware modifications made and testing of the modified motors conducted.

The loss of Challenger reduced the compatibility with the Centaur upper stage to one orbiter. We have begun action to procure the equipment necessary to make the Orbiter Discovery compatible with the Centaur upper stage to replace this lost capability. We are also continuing the development, testing and engineering support activities on the Centaur upper stage. As part of these activities we are conducting a thorough safety review to ensure that the Centaur will operate properly and safely in the Shuttle.

The FY 1986 Operating Plan for the original appropriation level totalled $7.656 billion. Under the Deficit Control Act sequestration process we have taken a reduction of $323 million for a revised FY 1986 plan of $7.333 billion.

We have sent you a revised operating plan for FY 1986. In that plan, we identified $147 million in offsets primarily from reduced operations costs which have been applied against increased funding requirements for science and applications programs, tracking and data and lost reimbursements. We have also requested that the Congress approve the appropriation transfer authority required to implement the changes brought about by the Deficit Control Act and the Challenger accident.

In FY 1987 we have tentatively identified approximately $500 million of offsets to cover extension of development and ground activity for a number of spacecraft projects, loss of Shuttle reimbursements, initial funding for replacement of the Tracking and Data Relay Satellite lost in the accident, continued operation of the tracking ground stations and the cost of sustaining the necessary contractor teams on affected projects. We also expect a net resulting savings available for the additional requirements in the space transportation area. At this time, these adjustments do not provide for major hardware changes which may be determined to be necessary from the Rogers Commission and our own investigations. Based upon anticipated recommendations from the Rogers Commission and our best assessment of the time needed to make the modifications to the solid rocket booster motors and other hardware or procedures changes, the next shuttle flight is planned for the summer of 1987.

Mr. Chairman, as you know, there is an ongoing interagency process to examine options and issues relating to the Challenger accident and how best to fund and implement the changes necessary. I am confident that we will determine and correct the causes of the Challenger accident and the shuttle will emerge as a stronger, safer system capable of meeting space launch needs for years to come. The introspection that NASA is undergoing as a result of this accident investigation will make NASA a stronger agency committed to innovation and technical excellence that will retain American preeminence in space into the next century. Space has been, and with the shuttle, our science activities and the Space Station, it will continue to be, an American frontier.

Mr. Chairman, this completes my prepared statement. I would be pleased to respond to questions you and other Members of the Subcommittee may have.

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To: NPC003 (57:NPC003)
From: WH-PRESS (EOP042) Posted: Thu 6-Mar-86 16:50 EST
Sys 64 (41)
Subject: FLETCHER

THE WHITE HOUSE

Office of the Press Secretary

For Immediate Release March 6, 1986

The President today announced his intention to nominate James C. Fletcher to be Administrator of the National Aeronautics and Space Administration. He would succeed James M. Beggs.

Dr. Fletcher is a consulting engineer and also serves as the Whiteford professor at the University of Pittsburgh. He served as the Administrator of the National Aeronautics and Space Administration in 1971-1977. He was the President of the University of Utah in 1964-1971.

He was a founder of Space Electronics Corporation in 1958 and served as President until 1960 when the company merged with Aerojet-General Corporation to form Space-General Corporation. He became President of Space-General Corporation in 1960 and served as Chairman of the Board in 1961-1964.

Dr. Fletcher served as a consultant, then member, of the President's Science Advisory Committee in 1958-1970 and a member of the Air Force Science Advisory Board in 1962-1967. He was made an associate fellow of the American Institute of Aeronautics and Astronautics in 1962 and a trustee of the Aerospace Education Foundation in 1966.

He graduated from Columbia University (A.B., 1940), California Institute of Technology (Ph.D., 1948) and Lehigh University (LL.D., 1978). He is married, has four children and resides in McLean, Virginia. He was born June 5, 1919 in Millburn, New Jersey.

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NASA
National Aeronautics and
Space Administration

Washington, D.C.
20546

Biographical
Data

WILLIAM R. GRAHAM
Acting Administrator of NASA

Dr. William R. Graham, a founder and executive of R&D Associates, Marina Del Rey, Calif., became acting administrator of the National Aeronautics and Space Administration on Dec. 4, 1985. Before assuming this position he was deputy administrator. Nominated for the deputy post by President Reagan on Sept. 12, Graham was confirmed by the Senate on Nov. 18 and took office on Nov. 25, 1985.

In 1980, Graham served as an advisor to candidate Ronald Reagan and was a member of the President-elect's transition team. Graham has served for the past 3 years as chairman of the General Advisory Committee on Arms Control and Disarmament, having been nominated by the President and confirmed by the Senate in 1982.

Before the founding of R&D Associates in 1971, Graham spent 6 years with the Rand Corp., Santa Monica, Calif. Prior to his employment at Rand, he served 3 years active duty as a project officer with the Air Force Weapons Laboratory, Kirtland Air Force Base, Albuquerque, N.M., directing a group conducting experimental and theoretical research on strategic system survivability.

Graham has been a consultant to the Office of the Secretary of Defense and has served on many international and national boards and advisory groups, including the National Academy of Science/National Research Council Committee on Undersea Warfare, the Air Force Science Advisory Board Task Force on Manned Strategic System Vulnerability, the U.S.-U.K. Joint Working Group on Atomic Weapons, the Defense Nuclear Agency Scientific Advisory Group on Effects, and the Defense Science Board System Vulnerability Task Force and Associated Task Forces.

His memberships in professional and honorary organizations include Tau Beta Pi, the American Institute for Aeronautics and Astronautics, the New York Academy of Science, the Council on Foreign Relations, the Board of Directors of the Committee on the Present Danger, the Defense Preparedness Association, the Ethics and Public Policy Center and the American Association for the Advancement of Science.

Born June 15, 1937, in San Antonio, Texas, Graham received a B.S. degree in physics from the California Institute of Technology in 1959. In addition, he earned an M.S. degree in engineering science in 1961, and a Ph.D. in electrical engineering in 1963, both from Stanford University.

He and his wife, Nina Winter Graham, have two children.

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January 8, 1986

NASA News

National Aeronautics and
Space Administration

Washington, D.C. 20546
AC 202-453-8400

David W. Garrett
Headquarters, Washington, D.C.
(Phone: 202/453-8400)

For Release:
Feb. 20, 1986
10:00 a.m. EST

RELEASE NO: 86-15

TRULY APPOINTED SPACE FLIGHT ASSOCIATE ADMINISTRATOR

Rear Admiral Richard H. Truly, USN, Commander of the Naval Space Command, has been appointed Associate Administrator for Space Flight, NASA Headquarters, effective immediately.

Truly will head NASA's Space Shuttle program and will assume direction of the agency's Design and Data Analysis Task Force which is reviewing the Shuttle Challenger accident of Jan. 28, 1986. In both roles, he succeeds Jesse W. Moore.

Moore will assume the post of Johnson Space Center Director, an appointment that was announced on Jan. 23.

Truly was designated a naval aviator in 1960. His initial tour of duty was in Fighter Squadron 33, where he flew F-8 Crusaders and made more than 300 carrier landings. From 1963 to 1965, he was first a student and later an instructor at the U.S. Air Force Aerospace Research Pilot School, Edwards Air Force Base, Calif. In 1965, he was among the initial military astronauts selected to the USAF Manned Orbiting Laboratory program. He became a NASA astronaut in 1969 and spent 14 years with NASA.

Truly was pilot for one of the two-man crews that flew the Shuttle Enterprise approach and landing test flights in 1977. He was then assigned as backup pilot for STS-1, the first orbital flight test of the Space Shuttle. His first space flight was STS-2 (Nov. 12-14, 1981) as pilot of the Shuttle Columbia. He was commander of STS-8 (Aug. 30-Sept. 5, 1983), the Shuttle Challenger, the first night launch and landing in the Shuttle program.

Truly became the first commander of the Naval Space Command upon its commissioning on Oct. 1, 1983. The Command is responsible for management and operational control of all Navy satellites in use and provides direct space system support to the fleet worldwide.

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After attending schools in Fayette and Meridian, Miss., Truly enrolled as an NROTC midshipman at the Georgia Institute of Technology in 1955. He received a bachelor of aeronautical engineering degree and was commissioned an Ensign in the U.S. Navy in 1959.

Truly has received numerous Defense, Navy and NASA awards. He also is the recipient of the Robert H. Goddard Memorial Trophy, the Thomas D. White Space Trophy and the Robert J. Collier Trophy.

Truly is married to the former Colleen Hanner of Milledgeville, Ga. They have three children.

- end -

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NASA
National Aeronautics and
Space Administration

Washington, D.C.
20546

Biographical Data

Dr. Raymond S. Colladay
Associate Administrator
Office of Aeronautics and Space Technology

Dr. Raymond S. Colladay was named Associate Administrator for Aeronautics and Space Technology at NASA Headquarters, Washington, D.C., on June 14, 1985, and since April 18, 1982, had served as Deputy Associate Administrator. As Associate Administrator, he is responsible for the planning, direction, execution and evaluation of NASA's Aeronautics and Space Technology programs and the institutional management of Ames Research Center, Langley Research Center and Lewis Research Center.

Colladay began his career with NASA Lewis Research Center, Cleveland, Ohio, in 1969, where he conducted analytical and experimental research in advanced, high temperature gas turbine engines. For the next two years he headed the Turbomachinery Fundamentals Section. He was then temporarily assigned to NASA Headquarters as Chief of the Propulsion Branch in the Aircraft Energy Efficiency Office. In 1977, he was named Assistant Manager of the Lewis Energy Efficiency Engine Project.

He returned to the Office of Aeronautics and Space Technology in 1979 as the Deputy Manager of the Advanced Propulsion Systems Office and later was Manager for Propulsion R&T. In 1981, he was named Director of the Research and Technology Division.

Colladay received a bachelor's degree in 1965, a master's degree in 1966, and a Ph.D. in 1969 from Michigan State University, East Lansing, Michigan. He has authored or co-authored more than 20 NASA technical reports and journal articles relating to aeronautical research. He is a member of Sigma Xi, Tau Beta Pi, Pi Tau Sigma, and Phi Kappa Phi. He is also a member of the American Institute of Aeronautics and Astronautics.

Born in Flint, Michigan, July 7, 1943, Colladay is married to the former Judith K. Rief. They have two daughters, Julie and Amy, and reside in Reston, Virginia.

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June, 1985

NASA
National Aeronautics and
Space Administration

Washington, D.C.
20546

Biographical Data

MR. JOHN E. O'BRIEN - GENERAL COUNSEL

John E. O'Brien has been NASA's General Counsel since August 4, 1985. He had previously been the NASA Deputy General Counsel since November 1981.

Prior to that Mr. O'Brien was NASA's Assistant General Counsel for Procurement Matters from March 1973 until November 8, 1981. He joined NASA in 1962 as a staff attorney at NASA's Launch Operations Center, now the Kennedy Space Center. Prior to that time he had served as a staff attorney of the Navy General Counsel's Office in Washington, DC from 1957-1962. In 1970 he was appointed Chief Counsel of the Kennedy Space Center and served in that position until his appointment as Assistant General Counsel for Procurement Matters. In 1976 he received the NASA Exceptional Service Medal and in 1980 he was awarded the Presidential Rank of Meritorious Executive.

Mr. O'Brien received a B.A. degree from Niagara University in 1953 and a Juris Doctorate degree from Georgetown University in 1957. During 1965-1966 he was a Princeton Fellow in Public Affairs at the Woodrow Wilson School of Public and International Affairs, Princeton University. He is a member of the Virginia Bar, the Federal Bar Association, and the American Bar Association.

John D. Hodge
Acting Associate Administrator
Office of Space Station

John Hodge is the Acting Associate Administrator for NASA's Office of Space Station. The Office of Space Station is responsible for the activities required to develop a permanently manned Space Station within a decade.

Mr. Hodge was appointed director of the Space Station Task Force when that organization was established in May 1982. He was appointed Deputy Director of the Interim Space Station Program Office in April 1984, when the Task Force completed its work. He directed activities that resulted in the initial concepts definition for Space Station, established program management policies, initiated advanced development programs, defined user needs and organized potential international cooperation.

Mr. Hodge was appointed Deputy Associate Administrator for Space Station on August 1, 1984, coinciding with the establishment of the Office of Space Station. Mr. Hodge joined NASA in 1959 after a distinguished career with Vickers-Armstrong, Ltd. in England and AVRO Aircraft, Ltd. in Canada. He was named Chief of Flight Control, supervising a team of over 200 technical and administrative personnel and 100 aerospace contractors and was Flight Director for Mercury, Gemini, and Apollo flights.

Mr. Hodge joined the Department of Transportation (DOT) in 1970 as Director of Transportation Systems Concepts at the Transportation Systems Center in Cambridge, Massachusetts. He later became Associate Administrator for Policy, Plans and Program Management in DOT's Research and Special Programs Administration, Washington, DC, until he rejoined NASA to head the Space Station Task Force. He received the DOT Secretary's Silver Medal for Meritorious Achievement in 1980.

Mr. Hodge was born in Leigh-on-Sea, Essex, England, and received a B.S. degree in engineering from Northampton Engineering College in London. He received the honorary degree of Doctor of Science from the City University, London, England, in 1966. In 1958, Mr. Hodge received the Arthur S. Fleming Award for Outstanding Young Men in the Federal Government.

4/8/86

PRESIDENTIAL DIRECTIVES

Mr. **Boland**. We will not get to most of the detailed questions on the budget and the justifications, perhaps today. But in any event, any of the staff here with you can respond to them.

I think one of the problems we have, as you have said in your statement, national policy drove us to the moon. Those were all Presidential decisions.

President Kennedy said, "We will go to the moon," and we came up with Apollo. And that cost some $20 billion. It was highly successful and really the glory days of NASA.

That was followed, of course, by President Nixon's decision to build the shuttle which now costs, as I understand—correct me if I am wrong—$18 billion to $19 billion, including the DOD costs.

Is that a fair figure?

Mr. **Newman**. That is fair.

Mr. **Boland**. Now, the Space Station, I don't know what that is going to cost. I looked at a figure around $14 billion. That is the next quantum leap into space. That was a Presidential decision by President Reagan. Whoever occupies the White House some years hence might very well make a Presidential decision to go to Mars, and put a man on Mars.

You hear about that—which would probably run I don't know how many billions of dollars, but that would be somewhere up in the billions, two or three billion.

But in any event, those are the areas where I think Congress has to be terribly interested in. Those are the big decisions. Those are the big costs that NASA comes up to justify. Those are the programs that cost the most money. That is where most of the problems occur, in those big programs.

As you have indicated, we have had great success. I think the shuttle, as I have indicated, has been a technological marvel, and it has been successful in doing the job that it was required to do.

It was sold, of course, on the basis of the fact that we were going to get rid of expendable vehicles.

We will get into that. I will carry you back probably eight or ten years to get a look at some of the hearings that this Committee had, with reference to whether or not we had seen the end of expendable vehicles or whether or not we would, as a result of pressure by the Department of Defense, continue to stay in the ELV field.

And they are important questions, and there is no doubt about it. The record reflects that at some point in time we would get rid of the ELVs, and that was one of the reasons why the shuttle was sold.

As you know, there is no dispute in my mind. I don't think there is much dispute in the minds of the Members who were sitting on this side of the table.

At the same time we recognized the fact that the shuttle is being called upon, and would be called upon, to do a lot more than it was anticipated it would do when it was first suggested that we build the shuttle.

So for that reason, of course, the cost of the shuttle has increased.

There is no way, I guess, that you can have a successfully manned Space Station without a space transportation system. Perhaps the most effective way and the best way to get that kind of a system is through the use of the shuttle.

Does anyone disagree with that? Is there any other way we can have an effective manned Space Station without the shuttle?

Dr. **Fletcher**. Mr. Chairman, I think that there is no economical way. There is always some visionary way that somebody might dream up, but I think the only practical way is through the space shuttle, yes.

NASA MANAGEMENT

Mr. **Boland**. Another area that this Committee is interested in, and I think justifiably so, is management. That is one area in which perhaps we can exercise a good deal of oversight because on the problems of cost and what particular vehicles cost, what the satellites cost, and what the particular research and development costs are for the particular programs that are justified, that is a judgment that has to be made by NASA itself.

And we have to accept your word for it. But in management—whether or not NASA is really managing this agency as effectively and efficiently as it should—that is an area that I think we will be getting into a bit.

Over the weekend, there were reports that echoed earlier indications that the management at Marshall ignored for five, six or seven years indications that the solid rocket boosters were not safe.

How do you feel about this, based on what the Rogers Commission's open hearings and on what NASA has learned, that the Marshall Space Flight Center or Headquarters or both ignored clear signals that the SRBs were not safe?

How stringent is the management of Headquarters with some of your Space Flight Centers?

Dr. **Fletcher**. Mr. Chairman, I would like to respond to that briefly, but I would hope that Dr. Graham and Admiral Truly would elaborate on whatever I might say.

First of all, the Rogers Commission report isn't finished, and I want to see the whole report before I comment.

Mr. **Boland**. I am glad you said it, because I am sure the Members on this side of the table want to see it. We will not comment much on the Rogers Commission, the Presidential Commission, because their conclusions have not been released yet.

I am sure that they will be presented to the White House within the next week or 10 days. I have a feeling the White House will not hold them very long, but will make a rather rapid release of the findings of the Rogers Commission.

And from stories that have been in the paper, from the way that Commission has acted, I think it deserves high praise. That is one of the reasons why no Committee on this side of the Capitol has gotten into the question of what happened. That was a question that had to be decided by the Rogers Commission, and if the committees on the Hill are dissatisfied with those conclusions and recommendations, they can pick the ball up and take it from there.

What about the management of NASA? You indicated changes have been made. I have the feeling, and it is perhaps unjustified, but I have the feeling that the centers almost run themselves.

They are happy with the success of their programs, and often, you know, familiarity breeds disaster, I guess, and success, great success, as some of the centers and NASA has had, sometimes breeds carelessness.

I wonder whether or not some of that has happened. How close is the management of the Headquarters to the Space Centers?

Dr. **Fletcher**. Mr. Chairman, I think you have put your finger on an important question. I think—I have the same intuitive feeling, but unfortunately, it is gained by reading newspaper accounts myself.

I am sure Dr. Graham and Admiral Truly have dug into it a lot further. But nevertheless, it is this uneasy feeling that you have, I share with you, and that is the main reason we have set up this Phillips Commission, to take a look at how we manage our programs.

What is the interrelationship between Headquarters and the Centers? How tight is that control? Not just on safety, but on all of these cost problems? That is exactly what we are going to try to do, and you might say, well, gentlemen, why does it take that long to look at our whole management structure?

I just have to remind you that General Phillips did the same thing for a portion of TRW. He took two years to do that study, and I would guess that six or eight months is about the minimum length of time to do that.

Whatever the case may be, I don't have all the answers right now, but I hope to come back to you at the end of this year and say, here is what we are going to do.

MANAGEMENT AT FIELD CENTERS

Mr. **Boland**. In your experience, Dr. Fletcher, do you think that the management is tight enough between Headquarters and the Centers?

Dr. **Fletcher**. I think——

Mr. **Boland**. Was it in your reign from 1971 to 1977?

Dr. **Fletcher**. Oh, during the reign of——

Mr. **Boland**. Has it eroded since that time?

Dr. **Fletcher**. I can't really say that it has eroded since that time, but there were signs of difficulties, even then, that it might have happened. I think it is premature for me to judge that without having really delved into it more deeply. I think, though, that Admiral Truly, who has dug into this a lot more than I have, can answer that better than I.

Mr. **Boland**. Yes?

Admiral **Truly**. Mr. Chairman——

Mr. **Boland**. Let me ask you, Admiral. You have had a lot of experience there, and we are delighted to see you in this organization because of your experience and your knowledge, and I would like to get from you whether you can indicate whether or not there is a special problem at Marshall.

Admiral **Truly**. Mr. Chairman, it is——

Mr. **Boland**. That is a tough question; you can dance around it if you want, but it is a difficult question. From all the information that has been filtered back, some of it in the press, we get the impression there are some problems at Marshall.

Admiral **Truly**. I believe that this accident and the resulting investigation which, as you have commented before, is not entirely complete, very clearly pointed up that despite the clear requirements in the documentation in the Space Shuttle program for problems with flight-critical items—that is, those that would endanger the loss of vehicle and/or crew in particular—there are clear requirements that problems of that nature filter clearly up the program chain prior to flight, and at the flight readiness reviews.

In the STS 51-L case, I think that the system for one reason or another, failed in the sense that this particular problem had been worked within the system, and yet in fact, the accident happened. Our findings in the NASA Task Force, and I am sure the conclusion of the Commission will be that the failure was one that should have been foreseen.

I think you have also hit on a problem that will have to be of special interest to General Phillips and his group, and that is the relationship of the programs and the major centers. I don't have the answer to that. I have reflected a great deal about it, and I am looking forward to the opportunity to speak with Dr. Fletcher and work with General Phillips and his group.

I think that the system that is set up for the Shuttle Program, that is the Level 1, Level 2 and Level 3 organizations, and the system that was envisioned and is in the requirements, is not necessarily a bad one.

I think it is a very good one. But something did go awry here, the result of which was the start of a very difficult situation that we now find ourselves in.

After taking the first actions that I did after I came on board to try to stabilize the investigation itself, I tried to devise a strategy so that we could safely get ourselves back to flight. It is comprehensive, and there are literally thousands of people at the centers and the contractors working on some phase or another of it now.

The first piece of that strategy was to review the program management of this system starting with the design requirements for the system, and going right through the progress of the information as it flows right up to the launch commit criteria. This was done to ensure that either the program management scheme that we have in place is the right one, or if it is not, adjust it where it should be adjusted.

That effort is barely started. We have primarily concentrated up to now on the identification of the specific problem, and also, a great deal of effort in trying to devise the best safe schedule that we think that is possible to achieve. That is one that results, as Dr. Fletcher mentioned, in a July 1987 launch.

PROGRAM MANAGEMENT

Mr. **Boland**. Let me ask some of those who have been there over the years whether or not there has been less monitoring of the Centers than had been done in years past?

Phil? Anybody? Somebody who has been there.

Dr. **Fletcher**. Phil Culbertson has been there the longest, Mr. Chairman.

Mr. **Culbertson**. Well, not the absolute longest.

Mr. **Boland**. You are in the Headquarters here. You have knowledge of what the Centers do, and I am wondering whether or not there is any feeling on the part of those who are in the Headquarters who are concerned about whether or not the centers were doing the job they had to do, whether or not at times they were even listening to Headquarters, and what sort of influence Headquarters had on the Centers.

Mr. **Culbertson**. Yes, I understand the question. As both Jim and Dick have said, it is a valid question. There were fundamental changes made between the way Apollo was managed and the way the shuttle was managed.

These were changes made, I guess, in 1971 and 1972, in what there was during Apollo. In part, because of the nature of the vehicle itself and the program, there was a very detailed management within Headquarters.

The responsibilities for the majority of the hardware was split relatively evenly between Houston and Marshall.

There was, in that case, in my view, a relatively simple interface that was required between the two of those centers. Each Center had an ability to carry out a fairly—I won't say autonomous—but each one had a clearly described role and responsibility within the program. Apollo was managed, as I say, out of Headquarters with somewhat larger Civil Service staff than we would have to have had, but with a lot of contract support directly supporting the Headquarters organization.

The decision was made, I guess, during the early days of Dr. Fletcher's earlier tenure here, that for the development of the shuttle, there would be a significant total program responsibility at the Johnson Space Center.

We called it the lead center responsibility. The management within Headquarters was still, I think, not at the same level of detail, because there was a responsibility that Johnson had in the technical area, which was broader than had been their responsibility in the Apollo program.

This was a decision that was made deliberately and after a lot of careful reflection by Jim and George Low, and Dale Myers, who was the Associate Administrator for the shuttle at that time.

I think it was extremely successful during the development phase, and I think it was merging into the operational phase, and it was and is merging into the more operational phase.

I think as a program that during the development of the shuttle that arrangement was successful. Obviously, we have to look at that.

REDUCED CIVILIAN PERSONNEL

Mr. **Boland**. Let me ask you whether or not, Phil, there has been some indication that the quality of the monitoring of the projects that NASA does, both in Headquarters and the Centers, has eroded because of lack of civilian personnel?

Is that true?

Mr. **Culbertson**. Of civil servants or contractors?

Mr. **Boland**. The NASA employees. Monitoring the projects that are handled by Headquarters or the Centers.

Mr. **Culbertson**. Over the years, we have gone from 37,000 down to 22,000 now. So, the numbers have shrunk. Has the quality diminished? I don't think the quality of individuals has diminished at the Headquarters or the Centers.

We have to look both at numbers and management styles, of course, and the quality of the people, too. The experience that the majority of the NASA people have is much greater than it was before, because we, in coming down in organizational size, your average age goes up, the experience has gone up, and we have talked about that here before.

So, certainly, the experience has gone up, and I think in a lot of respects, the judgment based on that experience has gone up.

Dr. **Fletcher**. Mr. Chairman, if I may comment?

Mr. **Boland**. Sure.

Dr. **Fletcher**. I think you have put your finger on an awful important question, because I have the same questions coming in now. I wonder about all this. But that is the very reason why we have put together this Phillips Committee, to address these things by people from outside, so that we can get an impartial review of what, how we manage our programs.

SPACE TELESCOPE COST INCREASE

Mr. **Boland**. I want to compliment NASA and you particularly for setting up this type of organization to look into it.

Let me point to one particular instance. Our hearings suggest that in the case of the telescope which went from—hold on to your hats—$495 million to $1.2 billion, there was a serious lack of oversight on the part of Headquarters.

Jim Beggs admitted that Marshall wasn't telling Headquarters how serious the problem was, and the contractor wasn't telling Marshall everything.

The problem surfaced about three years ago. It was, I guess, a hint of things to come.

Dr. **Fletcher**. Well——

Mr. **Boland**. What about that? Anybody know anything about that?

Dr. **Fletcher**. I can't comment on the increase of the cost of the space telescope, except for one thing, I was there at the beginning, at the birth, and it was a highly technical program.

It is the most advanced, high-technology program we probably have ever undertaken. This is the first real permanent observatory in space. I think, though, Dr. Edelson has followed that in some detail and could give you a better response than I as to what the very detailed reasons for that cost increase was.

But again, I want to say that that was a very, very high-technology program.

Mr. **Boland**. You never anticipated it was going to escalate from over $400 million to $1.2 billion, though, did you?

Dr. **Fletcher**. No, I did not, but on the other hand, I didn't anticipate a lot of things like inflation and whatnot. That wasn't a big problem when I left. It was in between times, though.

THIOKOL ENGINEER—RECOMMENDATION AGAINST LAUNCH

Mr. **Boland**. What about this—this surfaced the other day. I suppose I ought to ask the question here. What about the Thiokol engineer, Allen McDonald, with respect to his recommendations and what has happened to him?

He recommended against the launch of 51-L, and obviously, he was, or apparently, he was, disciplined for being forthright about it. Do you agree with the action that Thiokol took?

Dr. **Fletcher**. I am not sure of the details of that, and I would like to turn to Dr. Graham for that. But I would like to comment on the principle. NASA would never do that—would never punish somebody "punish" is the word the newspapers used—for being open with commissions or a Committee of Congress.

We don't operate that way. We generally let people say what they think.

Mr. **Boland**. You don't always follow their advice?

Dr. **Fletcher**. No, but we do it in the open. We have our battles, unfortunately, or fortunately, whichever way you want to look at it, in public. That is the way NASA is.

By and large, I don't know of very many instances, and if I did, I would certainly do something about it, wherever it happened in NASA. Having said that, I think I would have to turn to Dr. Graham to answer what happened with Thiokol, because I am not familiar with the case.

Mr. **Boland**. Are you familiar with it?

Dr. **Graham**. Yes, Mr. Chairman.

After the accident, I learned of Mr. McDonald's concern about the O-rings and began to look into the situation. Apparently, it was caused by a lack of communication within the structure of NASA itself.

About that time, the most senior management of Thiokol requested a meeting on February 21. I met with them at my office.

At that time, I stated to them that their policy of letting each of the employees of Thiokol speak freely and openly about the Challenger accident, without influence from either Morton Thiokol or from NASA, was in my view an extremely important principle to maintain throughout the investigation, and thereafter.

And I told them that should they at any time feel an attempt to influence them be made that they should contact either the Presidential Commission or me directly.

They said they would do that, and also said that no such influence had been sensed to that time. But they would proceed as I suggested, if such an influence were senses by them or reported to them within Thiokol.

I have checked within NASA and find no reports that NASA's staff were attempting to influence Thiokol in either the assignment of tasks or in the testimony that their employees provided to the Commission.

Nevertheless, I am concerned that either the appearance or possibly the substance of such influence might exist. Because of that, in coordination with Dr. Fletcher I have asked the NASA Inspector General to look into the situation, to see exactly what did transpire in terms of NASA's action regarding the contractor Thiokol and their personnel.

As you know, our IG independently reports to Congress, as well as to the NASA Administrator. He is a Presidential appointee and happens to be a former distinguished member of the Federal Bureau of Investigation.

I have a great deal of confidence in him, and in the work of his organization, to make sure that we fully understand the situation that occurred there. That work today is not yet complete.

Mr. **Boland**. I suppose that action taken at Thiokol is an example of, "take off your engineer's hat and put on your management hat," and I think McDonald refused to do that.

Mr. **Boland**. Mr. Green?

CONTINUITY WITHIN NASA'S PROGRAMS

Mr. **Green**. Thank you, Mr. Chairman.

Dr. Fletcher, few have come into a job facing as large a task as the one you face, and I know you bring a wealth of experience from your years both with NASA and from experience outside. You have my best wishes, and I am sure those of everybody on this Subcommittee.

One area that I am concerned with is that of the continuity within NASA's programs. You started, of course, with the moon landings, and then that program ended. There was no follow-on from it.

At that point, they had the Skylab missions, and ultimately that came to an end, and nothing seemed to flow from it.

You had, of course, throughout that period, the use of expendable launch vehicles carrying science payloads, unmanned vehicles, and it was contemplated that the shuttle would end the use of those.

We have had the shuttle. Now, we are talking about the Space Station. Beyond that, the next generation, a new launch vehicle, the transatmospheric vehicle, whatever you want to call it, doesn't seem to bear much relationship to the shuttle, but seems to be the next generation of launch vehicle that is contemplated.

Is this an evolutionary program, or are we simply leaping from one big ticket item to the next?

Dr. **Fletcher**. Mr. Green, I would be happy to answer that since I am familiar with most of the things that you described.

Starting with Apollo, we did finish what the President asked us to do. We landed men on the moon safely, and returned them, and in fact, we carried on for 10 more flights to make sure that we got the appropriate science from those missions. The lunar rover and most of the science came in the latter part of the Apollo mission.

We also used Apollo components for other missions, for example, the Skylab used the Saturn V booster and some older Saturn I-B boosters to place men in the Skylab and return them.

And then we actually followed on with an Apollo-Soyuz program, which had some science, but it also had international implications, all of that being part of the Apollo program.

We began to realize, however, that if we kept using Saturn Vs for launch vehicles, it would be horrendously expensive. We had to use the technology, but not the Saturn V itself. The technology developed on the Saturn program helped us come up with a less expensive launch vehicle, and basically, the Saturn technology was used as a starting point for the space shuttle main engine.

That engine pushed the state of the art to be sure, but it was in essence the hydrogen-oxygen high pump velocity technique used on the upper stage of Saturn.

The shuttle then seemed like a good way to proceed with the transportation system, not to replace all the expendable launch vehicles, although we believed there was a good chance it would replace most of them.

The shuttle was the transportation system of the future. On the other hand, we always had in mind there would be a permanent presence in space. Even back when I first came in, this was a goal of NASA. The transportation system—everybody says it was to compete with expendable launch vehicles, and so forth—that wasn't the main object of the space shuttle; it was to provide easy access to space for men and equipment and return them, as compared with the Apollo program, not the expendables.

The idea was that at the end of that shuttle development, we would have a Space Station. We couldn't do both the Space Station and the space shuttle at the same time with a limited budget. Maybe we should have tried, Mr. Chairman, but you remember the budget pressures on NASA.

I was having a hard time just keeping a level budget instead of going down. But nevertheless, there was light at the end of the tunnel, so the space station was the next logical step to move out on, and some day, we will have lots of people moving out permanently to occupy space.

The Space Station, as we call it, which is a space facility or, as somebody called it, infrastructure in space, is the next phase of this ongoing program. And we use as much of the shuttle technology as we can.

For example, the spacelab is a module, and I am sure a lot of that technology will go into the Space Station, although I would have to ask John Hodge to comment on that. I am sure that a lot of the technology, not the pieces, but the technology, derives from the Space Shuttle.

Certainly the components must fit in the space shuttle payload bay. So there may not seem to be continuity, but there is definitely continuity from Apollo on through the space station, and I expect beyond.

TRANSATMOSPHERIC VEHICLE

Mr. GREEN. What about the transatmospheric vehicle? That doesn't seem to build on the shuttle at all.

Dr. FLETCHER. I forgot that part of the question. That vehicle is another outgrowth of another part of NASA. Over the years, even when I was here, we had what we called a hypersonic research program, one item of which was a hypersonic test vehicle.

I don't remember what happened to the hypersonic test vehicle, but it was conceptually there, even in 1977. We had developed technology for a different kind of engine, which had to be a variable geometry engine, which is going to be used as I understand on the National Aerospace Plane.

The thermal protection system has always been a high-technology program in NASA for hypersonic flight. We used some of the thermal protection system in the space shuttle program, although that planned for the Space Station will be a different variety.

Ray Colladay is in charge of OAST and has the principal responsibility for the TAV, or NASP as we now call it.

So the NASP arose out of a different part of NASA, but remember, NASA has always had a dual function. It has the space function and the aeronautics function.

And the aeronautics function produces a lot of things, maybe not as dramatic in some people's minds as the NASP, but certainly has contributed indepth to both our civilian and our military aircraft. I can see items on a lot of our commercial aircraft that I knew had been developed in the Aeronautics program, when I was at NASA.

These winglets and things of that sort, all happened then. So, it is the Aeronautics piece of NASA that is giving rise to this aerospace plane, which is an experimental plane. It is not a transportation system yet. Now, some day, it may become so, but not yet. Do you want to add to that?

Dr. COLLADAY. I would just add one point, Dr. Fletcher, to respond to your question, Mr. Green. And that is that the Aerospace Plane does involve many of the technologies that we have gained experience on in the space shuttle. These include high-temperature materials and hot structures, reusable systems, as well as the space experiments on hypersonics in the upper atmosphere that we have had on every shuttle that has flown.

We have it heavily instrumented. That is a data base from which we are building for future generations. I don't know that it will be the next generation—but building the technology base for yet another generation of space transportation vehicles.

PURPOSE OF SPACE PROGRAM

Mr. GREEN. What do you see as the purpose of the program? You discussed the machinery.

Dr. FLETCHER. Mr. Green, the purpose of the program is to provide an experimental flight vehicle.

Mr. GREEN. I meant the purpose of the space program as a whole.

Dr. FLETCHER. Oh, the purpose of the space program as a whole is to develop scientific capabilities in space; to explore the solar system to the extent that we can; to use observatories, earth orbital observatories; to explore the whole universe, because we can't seem to get spacecraft beyond the solar system in the immediate future; to provide opportunities for industry in space; and to generally move all of us—industry, science and others including to some extent help the military when necessary—to make use of that area, that region we call space.

COMMUNICATIONS WITH ASAP

Mr. **Green**. Let me turn to an area that I think the Chairman has started on, but I would like to pursue a little further, and that is the seeming collapse in communications within NASA.

I refer particularly to the communications with the Aerospace Safety Advisory Panel (ASAP). The Panel I think was quite prescient in some ways. Their report covering calendar year 1984, for example, warned NASA not to consider the shuttle operational in the sense that an airline is operational, that it was always going to be much more precarious from a safety point of view than routine airline operations, and that NASA had to proceed accordingly.

They raised specific concerns, and as best one can see from the reports from 1985 and indeed for all preceding years, no one seems to have called the O-ring problem to their attention; at least the only mention of the solid fuel rocket boosters in the main body of the report is the reference to the filament wound boosters.

There is a brief mention in the appendix, where they list their work, simply a statement that the O-rings were working as they were supposed to, rather than the boosters were working as they were supposed to work; and all this came at a time when obviously, the people at Morton Thiokol recognized there was a problem, because they were coming up with a large number of suggested fixes for it.

Obviously, your staff knew they were doing it, and allowed them to spend NASA's time and money to do it, and yet, that information doesn't seem to have gotten to one of your main entities concerning safety.

How come?

Dr. **Fletcher**. Mr. Green, you have touched on another very important point, which I plan to look into in some depth personally, because I can do that. But I would like to turn as soon as I get through with an opening statement, to Dr. Graham, and Admiral Truly, to make sure what really did happen. But I can only comment on what I read in the newspapers.

We had a close working relationship with the Aerospace Safety Advisory Panel. It is a statutory body by the way, set up by Congress, and we felt an obligation to involve them in all aspects of safety. I don't know whether it is practical now, but that could include somebody to be down at the Cape during the flight readiness reviews, (FRRs).

I would be amazed if, when I was there at least, that problems of that sort weren't brought to the attention of the safety advisory board. They were pretty much on top of the risks that the Apollo program was subject to.

Why this particular problem wasn't brought to their attention, and how it has been functioning, I am really not current. I only know what I read in the papers again.

I would like to turn to Bill and Dick to respond to that.

SRM O-RING SEALS

Dr. **Graham**. Mr. Green, I think to some degree NASA was misled during its own test program in the development of the solid rocket boosters, because the erosion in the O-ring seals did not show up during the development, test and qualification program.

In retrospect, I know that was a deficiency in the test program, and one which we certainly intend to overcome in the test program that would lead to the redesign and requalification of that solid rocket booster.

Because it didn't show up then, the system was released for flight, and, in fact, it wasn't until the second flight of the shuttle that the first erosion appeared on the seals.

Mr. **Green**. That was when?

Dr. **Graham**. I have an expert on that next to me, because Admiral Truly was the pilot on that second flight.

Admiral **Truly**. November 14, 1981.

Dr. **Graham**. After the erosion began showing up, it was identified, but it is clear in retrospect that it was not properly perceived.

Again, I think part of that misperception was based on the fact that a generally similar, but certainly not identical, seal was used on the solid rocket booster segments on the very successful Titan booster system that the Air Force had used for many years and had used with great success. In fact, there had never been a flight failure of those seals. I believe there was one failure in a rocket motor test during an early part of the development program, but that was a ground test configuration.

So there were literally over 100 motor firings in 70 successful flights without a failure of the Titan program. Again, that gave what is in retrospect a false sense of security about the performance of those seals. I think the most worrisome part of this entire situation is that the discipline that NASA had learned during the Apollo program of creating very large and very complex and potentially very difficult systems to operate and to work all problems as if they were indeed flight and life safety critical problems, somehow was not fully carried through into the shuttle program. The sense of raising the issue and raising it through various channels in a significant way, and perceiving—I don't mean to place all the emphasis on the people who were on the shop floor—but at any rate, the sense of perceiving it was just not complete.

You have to understand that in the design of any very complex system such as this, errors will be introduced into the design at that point. People have a limitation, as do all of us, they are human, they can make mistakes.

The management challenge is to somehow make sure that enough review and discussion goes on about consideration of the experience and judgments of all levels of the organization that those mistakes are not allowed to persist in these catastrophic dimensions.

It didn't happen on the SRBs and that is, I believe, in substantial part the reason that Dr. Fletcher has initiated a top-to-bottom review of the management of the organizational structure of NASA, so that we can in fact recapture that ability to be self-critical and to identify problems before they reach major dimensions and not let them persist in the system.

Mr. **Green**. Would you comment?

Dr. **Graham**. Do you have anything to add, Admiral Truly?

Admiral **Truly**. No, I really don't. I think the ASAP panel has played an extremely valuable role in the past and that they and, as I mentioned earlier, certain portions of our structure either missed this problem, or possibly just as importantly, missed the significance of this problem. Among the thousands of hours that are spent within the system in dealing with safety, you know, every part of the system is dealt with every day. How this one weaved its way or didn't show in the system is the one that puzzles me, and when we have the report of the Commission and understand this, we can get with it.

As you know, there have already been suggestions within the system for some internal organizational changes to NASA to establish an independent safety organization that may go from top to bottom.

I personally don't think that every problem has an organizational solution, and I think that disciplining the system within a properly structured organization is something that is also another cure.

ASAP PERFORMING SAFETY AUDIT

Mr. **Green**. The panel doesn't have enough staff, does it, to perform a safety audit kind of function?

Admiral **Truly**. It is an oversight.

Dr. **Fletcher**. Mr. Green, it probably doesn't have enough staff to do that, but I think the question deserves to be raised whether it has adequate staff to do its function.

I plan to make sure that that happens.

Mr. **Green**. Would you think they ought to have enough staff to be able to do a safety audit function, as opposed to simply being a sounding board for problems?

Dr. **Fletcher**. No, safety audit—if I understand the term correctly, I think would be beyond them. We ought to be able to do safety audits within house and let ASAP ask searching questions, and they need adequate staff to be able to do that.

INTERNAL SAFETY AUDITS

Mr. **Green**. What sort of internal mechanism do you have now for the safety audit purposes?

Dr. **Fletcher**. I would have to defer that to somebody else. I don't know what happened, where it is now. Admiral Truly—some of us are new, Mr. Green.

Mr. **Culbertson**. The Office of Safety is a part of the Office of the Chief Engineer, and now as a matter of fact, the Deputy Chief Engineer who was, prior to being made Deputy, head of the Safety Office, within that office.

Each of the centers has its own safety office, and the principal responsibility of the Headquarters Safety Office is to establish policy and to provide an oversight of the overall program.

And the centers, to the best of my knowledge, each has their own safety office and staff.

Mr. **Green**. They would report to the head of the center rather than being independent of the center?

Mr. **Culbertson**. They report within the center, but they also report to the head of the Safety Office in Washington in a dual capacity. It is my belief they report in a dual capacity, at least I know that the head of the safety office does consider that each of the center heads of safety report to him in at least a policy and oversight way.

But let me also say that any safety office has to be supplemented. Safety is designed into and built into things, too, and so the safety offices are not the only people in an organization who must be very conscious of safety.

Dr. **Fletcher**. Mr. Green, could I just add something to that. I don't see Milt Silveira here today, but I think I will try to respond the best I can, because I have asked the same question of him, and quite frankly, having not been on board long enough, I have not really absorbed it.

There is a very close interaction between the safety audit functions in the centers and Milt Silveira's office. That interaction has always been close, and there is a dotted line, so to speak, to Milt's office, and if he sees something irregular, he has authority to say, "go back and change it."

So, there is a reasonably tight control over the safety audits of the center. I think if there were a comment, it would be, does Silveira have enough personnel to be able to conduct that in-depth review of the other safety auditors?

That is a question that we will have to look at.

CIVILIAN SPACE PROGRAM VS DEFENSE SPACE PROGRAM

Mr. **Green**. Let me turn to another area. Presently, the United States really has two space programs, a civilian one and a defense one. In fact, my understanding is that the military program has a budget of about twice that of NASA.

I have been told, for instance, that the military's program in robotics is projected to be about 10 times NASA's.

Could you tell me what the impact of the large defense space program is on NASA's ability to attract scientists and engineers to its portion of the space program?

Dr. **Fletcher**. Well, I can start out, Mr. Green, on that one, since I am familiar with the military program to some degree.

Space is becoming a place where we do things of all kinds. We do science, we do commercial things. We have discovered a new land, new frontier if you like, and the military is no exception to that.

They have found uses of space for their own purpose, most of them peaceful as you know, and they are moving out vigorously into space.

The process has not happened suddenly, but of course, it does happen over a period of, say, 10 years, and the question is, are we getting enough young people into the civilian program to be able to fill the shoes of the giants that accomplished all those things we talked about earlier?

I am under the impression—and I need somebody to correct me if it is wrong—that because of the excitement of the program and because of the public nature of our program, we compete rather well with the military for these youngsters out of school.

We are, like they, limited by the Civil Service restrictions, but NASA is still an exciting place to be, and of the youngsters coming out of school that are competent, I think we get our fair share.

If that is wrong, I hope somebody that knows better would correct me.

Mr. **Culbertson**. Why don't you ask Bob Nysmith?

Mr. **Nysmith**. I am Bob Nysmith, Associate Administrator for Management. We do compete quite well, and it still is due to the mission and the kind of work we do. As a matter of fact, we have seen some indications that the large growth in the DOD program is, in fact, getting more kids to take up aerospace engineering in college, because they see a future. So, rather than competing with the DOD, in many ways the total space program is providing that cadre that we both draw on, and we compete very well with the DOD. We have more difficulty competing with industry, because we have a salary disparity of about $5,000 that we give up, but we are getting high-quality people today.

Mr. **Green**. Just one suggestion. It might be helpful to us to have Dr. Silveira, the Chief Engineer, here this afternoon.

Mr. **O'Brien**. He is on travel status.

Dr. **Fletcher**. He is on travel, but we will get Guy Cohen, this afternoon, who is our R&QA and safety person.

EFFECTS OF THE SHUTTLE DELAY

Mr. **Green**. You mentioned a summer of 1987 start-up for shuttle flights. Can you tell us what the likely effects of the delay will be on the major science programs, the Galileo, Ulysses and the space telescope launches?

You are missing the first 1987 window for the two solar system probes, are you not?

Dr. **Fletcher**. Mr. Green, I will start answering that, but any details will have to be shifted over to Admiral Truly, and maybe he can't even answer that because, as I mentioned, the priorities are not yet established and the manifest for the first few flights is not firmed up.

I can say, though, that all the science flights and all the commercial flights and all the military flights will be impacted by the accident. We cannot fly them on the times that we expected to.

So there will be deep and important impacts on all of these missions.

Just what, just who will suffer the most and so forth, we will have to wait and see what comes out of that manifest.

Admiral Truly, do you want to comment further on that?

Admiral **Truly**. That is an excellent question and it is the one that is the next one that we have to answer. We have a very difficult scheduling problem within the orbiter vehicles as we return to space flight, say, next summer, July 1987.

Of the vehicles—one is instrumented for Vandenberg capability; one is configured for Centaur and we have taken initial efforts to configure a second one for Centaur. There are also major competing priorities within the national security payloads and the major planetary probes and the Hubble Space Telescope.

As we built a flight schedule to get back to flying, there are numerous threats to that schedule, schedule threats in various phases. So we are presently discussing with Dr. Fletcher precisely that first year of flight and which of the major payloads should be scheduled and in what order.

FLIGHT MANIFEST

Mr. GREEN. How many flights do you anticipate in that first year?

Admiral TRULY. We anticipate six to seven flights during that first year.

Mr. GREEN. That is the first 12 months you are talking about?

Admiral TRULY. In the first 12 months after flight. We are probably projecting a six to seven flight schedule. That difference is turning precisely on this question because the flows for preparing the payloads and the vehicles are different depending on the payload itself. That is the difference in six or seven. So we are presently struggling with that problem. We are very aware of the planetary windows and are dealing with that now in order to set those first payloads.

Once priorities have been set, then our people can look at the total backlog of payloads, be they national security, NASA, science or communications satellites that we already have ready and can get out the manifest, but the first year is most important to us.

STATUS OF CENTAUR

Mr. GREEN. I gather the status of the Centaur is pretty critical also.

Admiral TRULY. Yes, sir, it is.

Mr. GREEN. What is the story on that?

Admiral TRULY. Well, I should—

Mr. BOLAND. Those two particular missions, the Centaur planetary missions are probably the most complex missions ever flown on the shuttle, Galileo and Ulysses, isn't that so?

Admiral TRULY. They are certainly among the most complex. I never thought of it quite that way.

As you know, we have had in place and have in place a major review of the shuttle Centaur system that is not scheduled to be included in an independent safety review of it. That independent safety review is not scheduled to be completed until towards the end of this year.

In order to get a quicker assessment in the proper amount of detail so that Dr. Fletcher can take a look at it, we have initiated a several week review involving all the centers and the program offices and the major contractor. Based on the data and our analysis of the system, I hope to bring that assessment to him within the next several weeks so that he, in turn, can address that and bring it to fruition.

Mr. GREEN. Would Centaur have been available for a May flight if it had not been for the Challenger disaster?

Admiral **Truly**. I would be surprised if it would have, considering the problems I now understand to have been faced. I wasn't here at the time, but that program was, as you know, running into a number of issues with the hardware and involving safety.

Mr. **Green**. Cryogenics.

Admiral **Truly**. And the high energy upper stage primarily. Whether or not it would have flown on schedule this summer, I don't know.

EXPENDABLE LAUNCH VEHICLES

Mr. **Green**. Will you also be asking for an additional expendable launch vehicle capacity?

Dr. **Fletcher**. Mr. Green, when you say "we," I assume you are addressing the question of NASA. I think the country will have to go for an additional expendable launch vehicle capability.

Mr. **Green**. I understand you first announced yesterday you were seeking an additional capability.

Dr. **Fletcher**. At the present time, NASA has not addressed that problem in detail. We don't anticipate requiring extra expendable launch vehicles, but I think that is still an open question.

Mr. **Green**. You wouldn't see expendable launch vehicles as a means for dealing with some of the backlog in launches?

Dr. **Fletcher**. I think the ELVs will be handling some of that backlog, but whether or not NASA will support them is something we have not addressed. It is unlikely that NASA would.

COMMERCIAL LAUNCH REQUIREMENT

Mr. **Green**. What about their potential for handling some of the commercial launches?

Dr. **Fletcher**. That issue is a very cogent issue because it is an issue that has to be addressed across-the-board. As you know, Congress mandated, or maybe it was the Executive Order, that the Department of Transportation would deal with the commercialization of expendable launch vehicles and so there is an interagency group which is dealing with that problem.

I think we are a member of that group and we are following the progress, but that also is a very complicated problem just as Admiral Truly's problem is complicated. It involves making sure that whatever customers we committed to on the shuttle are somehow taken care of one way or the other, commercial, or private, or DOD vehicles, or the shuttle.

It also involves investment of some kind and, if it is private investment, they have to have some assurance that they are going to get, not positive assurance, some assurance that they will get a return on their investment.

So it gets to be a very complicated, complex problem, and I think it will be some weeks before that is worked through. We are not playing the major role in that issue.

We are a part of the process, however.

Mr. **Green**. Thank you.

FUTURE OF SHUTTLE CENTAUR

Mr. **BOLAND**. We will be getting into the question of expendables vis-a-vis the shuttle and some of the commercial flights and so on in this area later on.

With respect to the manifests on the six flights that are projected, of course, that manifest I suppose will be driven in part by what happens to Centaur. Is that correct?

Admiral **TRULY**. Yes.

Mr. **BOLAND**. You are still looking very carefully at that. As a matter of fact, this Committee was the father and the mother of the Centaur program in the sense that we thought that would be the vehicle that ought to be using the upper stage; finally, research came around to that decision.

But as you know, our Survey and Investigations staff is about to give us their assessment of Centaur and whether it can safely be flown. Of course, NASA itself is looking at this very same problem to determine whether it can be safely flown.

If not, fine. It was a nice effort made, and we would not expect it to fly if it can't be flown safely.

Mr. Traxler, sorry it took so long to get to you.

IMPACT OF SHUTTLE ACCIDENT

Mr. **TRAXLER**. Your questions are always most appreciative. Thank you for the opportunity to comment.

We begin our hearings on the 1987 proposed budget for the National Aeronautics and Space Administration, and our hearings come at a time when NASA is undergoing the most intense public and private scrutiny in its 28 year history.

We are all mindful of the recent events and most particularly the tragic loss of Challenger and crew in January. That loss has caused us to focus on questions that must be addressed now as our program of manned space flight and exploration is of necessity grounded until July of 1987 at the earliest—that is your target date?

Dr. **FLETCHER**. The target date is July; that is correct, Mr. Traxler.

Mr. **TRAXLER**. Taking into account the various elements that you outlined for us, safety, scheduling, slippage, and I am sure we are all pleased and hopeful that you can make that date.

As we review this question, we are all mindful that the Presidential Commission will release its findings in the very near future and I hope we in the Congress are especially mindful of that report, the conclusions and its recommendations.

However, we must also consider in the coming months initiatives underway and whether they should be redirected or eliminated to make way for a fourth orbiter in the event that that is the decision that is made.

Should the Advanced Communications Technology Satellite be abandoned even as the pre-accident budget called for?

Another question is, should the Space Station development be slowed to provide funding for the fourth orbiter?

The other question is, can our Space Station development be slowed in view of the strong commitments we have made in this direction?

I mentioned these two areas only because of immediate concerns and they represent the very basic dilemma that will be confronting the Administration and the Congress and that is what are the hard choices and where will the money come from.

With virtually all of NASA's launchers now in doubt or due for significant overhaul, I wonder whether a combined program of shuttles and expendables could not be devised that would be superior to the one that stresses man's flight to the extent that we have in the past.

On the other hand, I am very open to the argument that having three orbiters exposes us to the prospect of having only two, God forbid we should lose another, and what that would mean for our capabilities in space, most especially development of a manned Space Station. I think we need to develop further our considerations in this area.

Above all, I hope that we can work together, this Committee, the agency, the Administration, to find an assured and balanced approach to all of our needs in space. Our space exploration, our space research efforts, they need to be balanced with respect to the financial resources available to us, and what we are able to commit to this effort.

We are concerned about the research and engineering requirements. We are worried about the balance in providing ourselves with the greatest possible flexibility to deal with the changing technologies and budget circumstances.

We will continue, in my judgment, to send men and women into space. I believe we belong in space.

Our quest at exploration is as inevitable as the sun's rising each day. But on the other hand, as one who has been very skeptical about sending civilians into space, whether they be Members of Congress or other civilian professionals, I must tell you that I am very concerned about the future of the so-called Civilian in Space Program.

You have touched upon the difficulties that you are having devising your manifest for the flights as they begin to resume, hopefully in July 1987.

Given the concerns about the choices in those cargoes, one must logically ask whether it is reasonable to expect that we would turn to such a high media visibility issue as a civilian in space taking up very valuable space, pounds that could perhaps be devoted to mission specialists who would be devoted to the technology of the reason for that mission.

CIVILIAN IN SPACE PROGRAM

So I must ask you at this point, are you as you look at your manifest, as you look at your cargo, are you really strongly considering in those early flights returning to a civilian-in-space concept?

Dr. FLETCHER. Are you addressing that to me, Mr. Traxler?

Mr. TRAXLER. You have been here 24 hours, Doctor.

Dr. FLETCHER. I do have thoughts on that subject.

Mr. **Traxler**. We would be interested in hearing them.

Dr. **Fletcher**. I think in the long term, and I don't want to define long term right now, but in the long term citizens need to be in space, because some day our children will all have that opportunity. There will be colonies in space. There will be what we call the Space Station, but this is the space facility that we are talking about.

So there will be lots of opportunities for civilians to be in space.

Having said that, you come back to the question of whether the shuttle should have a program with citizens in space. I have always believed that was a good idea in the past simply because I don't think the experiences which must be magnificent—I haven't been there myself, as you know—should not be confined to an elite few that happen to be successful in getting a payload on the shuttle and so forth.

Ordinary people should have an opportunity to fly, and I think the school teacher was a good idea myself. I didn't originate it, so I can comment freely. School teachers, you know, have done a heroic thing for this country and we don't appreciate them often. They educate our children. They are the next generation. So it is important to highlight the school teachers.

Having said that, our first priority is to get back on track safely and reliably and to take care of our high priority missions. I would be surprised if we had very many citizens in space in the early days of the program, but that is Jim Fletcher speaking, and I have not really reviewed what Admiral Truly is doing so we will have to see how he responds.

Mr. **Traxler**. The ball is down to you, Admiral.

Admiral **Truly**. First of all, I was on the NASA task force that was asked by the Administrator to consider the Citizens In Space Program. At the time I was in the Astronaut Office and I came to that task force with a sort of test pilot background and a very negative opinion at the start of it, but I must tell you that at the end I felt that this small group that spent quite a while looking at it as a policy issue—supported it in concept.

Things have changed, however, now, and we are down for a considerable period of time. We have a number of commitments that were made prior to the accident of what I would call people that are in the category other than pilots and mission specialists to fly on various missions. I have talked very briefly with Dr. Fletcher and hope to raise the issue with him again as we reconsider flying persons not in a pilot or missions specialist category, how we would fit them into the flights and plan for them properly.

But I do think it is an issue that needs a re-look.

INTERNAL OPERATIONS WITHIN NASA

Mr. **Traxler**. Thank you.

I want to turn for a moment back to the issue of internal operations within the agency.

I am curious how in view of the information that we have received concerning the Thiokol memo of July 1985 to NASA detailing the simulated experiments on the O-ring control for temperatures and that report which allegedly concludes that the O-ring would possibly fail below 50 degrees temperature. I am curious. Would you explain to the Committee how that memo, that type of memo, is handled within the agency?

The contractor prepares this analysis, and I am sure you get many of those. I think that is an important point, also, you might want to touch upon.

How is it internally handled? Where does it go? Are there multiple copies?

How many people get to see this? How is it digested so it is computed along with a lot of other information as to the safety requirements for the shuttle at certain temperatures?

Dr. **Fletcher**. Mr. Traxler, that is one I am really not on top of.

Mr. **Traxler**. You can lateral that one.

Dr. **Fletcher**. I will have to shoot that one to Dick Truly, also.

Admiral **Truly**. Let me answer this generally because I am not personally familiar with that. I am familiar that that memo surfaced, but in general a concern that was stated on a critical item by a contractor normally would be taken up first within his own office and then passed up to the level three project office, in this case, the Solid Rocket Booster Project Office at Marshall.

Along the way there are thousands of concerns in systems like the shuttle that are dealt with normally and routinely. As it is passed up and dispositioned, it should be and is looked at both from a technical point of view and if it is serious enough, it should also be looked at in the clear light of day in the glare of an independent safety look. That is generally the way it should be and is handled.

The puzzling situation of this particular part of the system—where now in retrospect and in digging through so much paper and talking to so many people—is that apparently there were flags raised along the way. The fact that at some point that did not get through the system is the very fact that it has received so much publicity, but it is also the very fact that is of the most concern to us as we look at the organization and look at the discipline as we go back to fly again.

We are determined that it will not and cannot happen again.

Mr. **Traxler**. I am sure, however, the next several days you will be able to give more detailed explanation to the Committee as to how those types of safety missiles, epistles, are internally handled within the agency and track them for us, if you would, please.

Clearly, it is of concern to us. I know it is of equal concern to you.

Admiral **Truly**. Yes, sir.

TEMPERATURE AND FUTURE FLIGHTS

Mr. **Traxler**. If, indeed, that particular concern on the part of the contractor was correct, and he is talking about not launching below 50 degrees, that would pretty well stall the efforts at Cape Kennedy in terms of winter flights with that type of equipment.

Would that be a fair assessment of one of the consequences of the validity of that memo?

Admiral **Truly**. Clearly if there are constraints on any part of the system that are temperature related, you are exactly right. That would not be a constraint on future flights for this particular joint because one of the requirements on the fix is that the new design will be that we environmentally controlled and we will qualify it to a new set of criteria which I am sure will be lower than 50 degrees in the redesigned joint case—if I understand your question correctly.

Mr. **Traxler**. That is correct. That was my question.

I appreciate the fact that we will be awaiting the Commission's report and I am sure there will be more information there. I am sure you will have more to say at some other time about your redesign efforts and what you are going to build the new system to.

I would just be concerned about that temperature and the fact that the temperatures on those mornings at Cape Kennedy can be substantially below those levels and could certainly have impinged upon your flight schedules causing considerable delays.

Admiral **Truly**. Yes, sir.

Mr. **Traxler**. Mr. Chairman, I have no further questions at this time.

Mr. **Boland**. Thank you very much.

Mr. Coughlin.

Mr. **Coughlin**. Thank you very much, Mr. Chairman.

Welcome back before this Subcommittee.

Dr. **Fletcher**. Nice to see you again.

COUGHLIN INTRODUCTORY

Mr. **Coughlin**. Nice to see you, and nice to have your team here. Back in 1957 I was a foreman on a production line making afterburners with Pratt and Whitney and new crane sections for Allison. That was considered to be pretty high technology, to be able to weld and work with those exotic materials, that are not very exotic today.

Suddenly Sputnik went up and we panicked. The Soviets had space technology and we didn't.

I found myself as a young foreman assigned at Aberdeen Proving Ground to see if we could build solid propellant casings, working with Thiokol Chemical. Engineers would really design it on the back of an envelope and say can you build this? We would weld it and machine it and take it down to Aberdeen and stuff it full of solid propellant by hand and take it out on the test range and blow it up, and go back and rework it again.

All of that gave me immense respect for both the Government agencies involved in our space program and for the contractors involved in our space program because there was never any compromise with quality. There was never any compromise either in the private sector companies or in our space effort, in our real haste to catch up with Sputnik.

We didn't compromise safety or quality as I saw it.

In 1971, Mr. Chairman, I served on the authorizing committee when the space shuttle was authorized and I have been on the appropriating side of the space program ever since. And again, although I have sometimes had some questions about the cost-effectiveness of what we were doing in certain instances, I have never had any concern about the quality of our efforts and about the consciousness and safety consciousness of the people in NASA or of our contractors.

As you mentioned, Mr. Chairman, I have known practically all of the astronauts who have flown in the space shuttle and in our space program. All of them knew there were risks involved. We were on the cutting edge of technology, yet they did it because they believed in the project, believed in the future, and believed it was necessary for our country and for the benefit of mankind. They did remarkable things in communications and national defense and medicine and such mundane things as weather forecasting. Through them we now have a better knowledge of our earth and universe that have all been of tremendous benefit.

SAFETY PROCEDURES

Frankly, Mr. Chairman, and I will come to my question in just a moment, I would fly that shuttle tomorrow with the same O-ring and same configuration in warm weather. I have that much confidence in NASA and its contractors.

Certainly there are improvements that can be made in safety and safety procedures. I know that Bill Rogers is a good friend. I hope we don't get bogged down in complexity because I think it is time to move ahead frankly.

I think our people acknowledge our great resources and somehow we don't need another Sputnik panic to bring me back to where I began. So I would like to ask you, Doctor, and Admiral, would you be willing to fly that bird tomorrow with the same O-ring configurations in warm weather?

Dr. **Fletcher**. Mr. Coughlin, you already know the answer from me. I would fly it, of course, in warm weather. However, having said that, I don't think we can ignore the accident. It was a traumatic experience for the whole country. It was certainly a traumatic experience for all of us in NASA, or alumni of NASA, and I think it is appropriate that we stand down for a period of time while we reexamine the whole enchillada, so to speak, as Admiral Truly is doing. We will not only fix the problem so we can operate in cold weather as well as warm weather, but also take care of all the other marginal things about that seal. At the same time, while standing down, we should take a look at our whole procedures which may or may not be faulty, the communications, and how we do our quality control, Admiral Truly is doing all that.

It seems to me that when there is a trauma of this sort, that is the thing you ought to be doing. I think as a result, Mr. Coughlin, we are going to be better than we were before the accident and better than we were during the follow up days. If we do it right, that is what will happen as a result of this thorough review.

Mr. **Coughlin**. Admiral, how about you, would you fly that bird in warm weather?

Admiral **Truly**. Your question is a hypothetical one.

Mr. **Coughlin**. It is a very specific one.

Admiral **Truly**. No, I would prefer to wait on the figures that we are working on. I would comment that had we done the testing after STS-2, when we first saw the first erosion, that we have done since the accident, we would have learned an incredible amount about the design and performance of that joint. And had we done that amount of testing at that time, I am sure we would have stood down and redesigned it at that time.

REDESIGN OF THE SHUTTLE

Mr. **Coughlin**. Is 1987 as fast as you can redesign and get a quick fix and relaunch?

Admiral **Truly**. I firmly believe it is, and it is primarily driven by not the specific fix itself but by the test and qualification firings that we will necessarily do to prove the fix meets the requirements.

Dr. **Fletcher**. I would like to add, and I cannot resist, the difference between Admiral Truly's answer and mine is very apparent. He has already flown in space and I never have.

NATIONAL SECURITY

Mr. **Coughlin**. Let me ask you, if it were necessary for national security purposes, how quickly could you launch again?

Dr. **Fletcher**. It depends. I will have to start out. It depends really on the nature of the emergency. If it were a military venture which is crucial to the Nation, I suspect heroic methods might be done although I really haven't examined this in detail.

On the other hand, if it is an ongoing intelligence mission which is important, but not crucial immediately to the Nation, then I think we ought to follow Admiral Truly's plan. That is just an off the top of the head comment without having reviewed in detail all of the things that are going on in Admiral Truly's shop.

But I think the kind of emergency that we are facing here is not of that first kind. We are not facing any immediate threat of war or anything of that sort. So heroic methods of that sort, I don't think, are called for.

Admiral Truly, you may want to have a different answer for that one.

Admiral **Truly**. I think if directed to, the system would take many, many weeks to prepare a vehicle, stack it and so forth, and we have no contingency plans that I have worked on to do that.

I frankly think that a much more reasonable solution if we did have a national emergency would be to fly the payload on the Titan rather than the shuttle. I really think that we must fix the problem that we have and I do think we must get back into flight as soon as we can, but not with a safety risk.

Incidentally, that July 1987 is no easy schedule to meet but there is not a safety risk in it. If we get in there and fire a motor and the new design doesn't meet the requirements, we won't fly until we have done it right. But I do think it is important to keep the pressure on the system to try to get the Nation's space program going again, but with no compromise to the redesign of that joint or the retest of it.

SPACE STATION SCHEDULE

Mr. **Coughlin**. In response to questions from the Chairman, and we will focus on this in more detail as we go through these hearings, you indicated that the space shuttle was necessary for the construction of the Space Station, and you will be asking us for funds for the Space Station this year. It would look at least to this observer as if there will be some slippage in the schedule for the Space Station.

I would like you to comment on that, whether that is not really a foregone conclusion that there will be some slippage in the Space Station, and then what should we be doing this year about the appropriation of money for it?

Dr. FLETCHER. With regard to the Space Station slippage, I am on top of that problem. I think that would be a disastrous thing for NASA to accept at this time. We don't want to slip the Space Station because of an accident happening on the shuttle. The only conceivable reason for doing that is if there is some funding limitation. There is no technical relationship between the accident and design of the Space Station.

For technical reasons or for policy reasons, there is no reason to slip the Space Station.

Having said that, I have to remind everybody that, from our point of view at least, the Space Station is a national effort, again like the Apollo program. So both the Americans on this side of the ocean and the Europeans and Japanese are all expecting us to live up to our commitments. They are depending on, in fact some of them are involved in construction of the development of the Space Station.

I should mention the Canadians who are also on this side of the ocean.

It seems like it would be a rather foolish thing to do to even suggest a slippage of the Space Station in order to fix the shuttle. That is just my comment. Maybe John Hodge or Admiral Truly or somebody else would want to make some different comment, but that is where I stand on it.

PRICING OF SHUTTLE PARTS

Mr. COUGHLIN. Let me also ask, I know that you are aware of the figures that have been printed in the *Miami Herald* and reprinted in the *Philadelphia Inquirer* which detail excessive pricing on parts in connection with the space shuttle program. I guess it is distressing to hear this come up in an agency that is under the jurisdiction of this Subcommittee and for which we appropriate money, and I wonder if you might comment on the results of your investigation into those questions that were raised about $159,000 spent for a cooling system built for $5000 and a $6.3 million lease of warehouse space next door to vacant Government buildings and some other charges.

Have you looked into those?

Dr. FLETCHER. Mr. Coughlin, I have looked into a few of those because some of the articles appeared in the newspaper at the time I was going through my confirmation hearings, and I felt obliged to at least check on some of them. There were an awful lot of statements made in that article, and those particular ones that you referred to, I did not look into. I am sure that there was some evidence of it but again you have to look at the other side.

You have to look at what our response to those allegations was, and actually Tommy Newman sitting next to me has looked into it in somewhat more detail.

I don't know whether he can answer those particular ones.

Mr. Boland. I wonder if we can hold that one, Larry, for the reason that we have our own S&I looking into this. As the Administrator so well said, there are two sides to the question. I have read some of the answers given by NASA to the two long stories in the *New York Times* and I think some of them are a little general. One of the reasons we thought we ought to look at it ourselves is precisely for that reason, to be sure that we have an objective look at the stories that were in the *Times* and we will be doing that.

Mr. Coughlin. Thank you, Mr. Chairman. I will hold on that.

Just let me say, this is not a further question and I will conclude. I think it will be important as we go through these hearings for us, at least for me, to understand what you are asking us to appropriate money for this year, particularly since we are not flying the shuttle, and I guess we will get to more detail as we go along.

Thank you, Mr. Chairman.

Mr. Boland. We will recess and come back to this sauna at 2 this afternoon.

[Recess]

Afternoon Session

MR. STOKES' INTRODUCTORY

Mr. Boland. The Committee will come to order.

I will recognize Mr. Stokes.

Mr. Stokes. Thank you, Mr. Chairman.

Dr. Fletcher, I want to also welcome you and your staff back this afternoon. I am delighted that you are here with us today, and I congratulate you being chosen and confirmed as the new Administrator of NASA.

You take on the reins of leadership of this very distinguished agency at a very difficult time in its short history.

While other Administrators have only had to face the question, "Where are we going?" you must also ask, "Where have we been?".

Dr. Fletcher. That is right.

Mr. Stokes. The questions you must face in the coming months will not be easy to find answers to, and as experience is telling you. Today, the eyes of the Nation will, of course, be on your efforts.

In this regard, I want to join with my colleagues in sharing my hopes that together we will soon be able to correct some of the problems that NASA is having today and be able to see this agency move forward in a manner which is safe, cost effective, and serves as a source of pride for ourselves, for the Nation and for our own children.

ESA AGREEMENTS

Let me begin the questions by asking you, how close are we to being able to finalize agreements with the European Space Agency, ESA, in regard to the contributions they are going to make to the Space Station?

Dr. FLETCHER. Mr. Stokes, I have not been in the middle of the Space Station discussions. I have had a briefing on it, but in terms of the various interactions with ESA and the other people involved in the Space Station, I am really not on top of that program, so I will have to turn to Mr. Hodge to answer that question.

Mr. STOKES. Sure.

Mr. HODGE. We had our program meetings with ESA just before Christmas; that was under the terms of the memorandum of understanding we had for the conduct of Phase B.

At that time they proposed a set of hardware to go into what is called Phase 2-B which is in the April time frame. What they proposed was not acceptable to us, and we said so.

They went back and re-grouped. We told them what was acceptable. In February we reached what is called a "program agreement."

In other words, the head of the space agency program in ESA and I signed a joint memorandum where we had agreed on what was a reasonable set of things.

Basically, that amounted to a permanently attached module which would be a general science module, plus a polar orbiting platform, and a co-orbiting platform.

Subsequent to that, ESA was not able to ratify that through the governments, the various governments that they have to deal with. They have to coordinate efforts with 14 countries.

And then beyond that, Director General Luest of ESA sent a memorandum to Dr. Graham that said that they would appreciate it if we would continue the program on the basis of that agreement which we have done.

In other words, they have been working with us on the basis of an agreement that has not yet been ratified by that council of ministers.

Mr. STOKES. I see.

Mr. HODGE. We are meeting with ESA the week after next to begin those negotiations again.

I have every confidence that, in fact, we will come to a reasonable conclusion within the next four or five weeks.

In the meantime, the ESA people are working with us in the engineering sense down at Houston with John Aaron and his people and are participating fully in the program, and I have every confidence that we will bring that to closure quickly.

Mr. STOKES. So that looks very positive.

Mr. HODGE. Yes.

SPACE STATION AND THE FOURTH ORBITER

Mr. STOKES. NASA has repeatedly commented it will not have the capability to place a Space Station into orbit unless it has the use of four shuttles.

Isn't it true that even if we built a new shuttle, the orbiter Columbia is not up to full capability, and couldn't carry the weight that would be needed in order to assist with assembly of the Space Station?

Mr. HODGE. On the basis of the designs we have done to date we see a need for somewhere between eight and ten shuttle launches per year for the two years that it is going to take to put the Space Station together, to assemble it. Then it will take eight to ten flights per year beyond that to service the Space Station.

Of those early missions, the ones associated with assembly, only a very few of them require the capacity, full capacity of the shuttle.

We have an agreement with Admiral Truly's organization that says that for certain flights we can fly up to 42,000 pounds to the orbit we require for the Space Station, and on a routine basis 38,000 pounds.

We only need four or five of those flights at 42,000 pounds which requires, I believe, 109 percent shuttle engine thrust.

That is the agreement we put together last year, and since the accident and the rescheduling that Admiral Truly is doing, we are beginning to work with them again to be sure that they are still valid numbers to use.

So far, we can put all the elements that have gone through preliminary design in the shuttle as it was before the January 28 period.

MANNED VS MAN-TENDED SPACE STATION

Mr. STOKES. Let me ask you this. Now that we just about completed Phase B of the Station's development, is there anything new that can be added to the argument over whether the Space Station should be manned or unmanned?

Mr. HODGE. We sent over to Congress yesterday the man-tended report that was due under the agreement we made, I think it was last year, sir, in the appropriations hearings.

What we have tried to do—what we have done, in fact, in the assembly sequence that we put together, is to allow for the possibility of halting the sequence at a time when it is in a man-tended phase.

This is after about the fifth or sixth launch. We will, in fact, have a situation where it will be unmanned, but will have a laboratory on board. It will have attached payloads, too.

So we could stop at that time. The proposal we make is that we go through that period and continue the launches until the system is manned in early 1994, and beyond that complete the baseline configuration that we have established.

SPACE PROGRAM PRIORITIES

Mr. STOKES. I see.

Dr. Fletcher, let me come back to you. During the history of NASA, I think each Administrator has taken a great deal of pride in leaving his own hand print or footprint upon the agency and as I said in my opening remarks, you come on the scene particularly at an interesting time in the agency's history. Although you are new to the agency in the sense of being back on the job—you are not new in the sense of having been there before.

Dr. FLETCHER. I think they call it a retread, Mr. Stokes.

Mr. STOKES. Retread. I think that is a good name for it.

I wonder if you would share with us some of your philosophy of where you would like to see the agency go or what you would like to be able to go in terms of your management approach.

Dr. FLETCHER. Mr. Stokes, that is an awfully good question.

The immediate problem is pretty clear to all of us. We have got to get the shuttle flying again safely and reliably. And then immediately thereafter we have got to make sure that we carry out the missions that have been already assigned to us which has been mentioned earlier.

Beyond that—and I think NASA does have to keep its eye on the future. It is a future-oriented agency, and it is designed to be that way. We have got to think in terms of moving out into space and in a variety of ways. We have to move out and explore the solar system.

There are a number of things we can do in that regard, both unmanned missions and someday maybe manned missions—but not with the current budget restrictions. We have to keep our eye on the future, nevertheless. Also, other observatories in space look out into the universe. That is part of our assignment. Also, to just move men and equipment out beyond near Earth's orbit is a good plan that arises in the space arena.

Moving to the other side, we have the aeronautics program, and I still think the U.S. is the leader in aeronautics, both civilian and militarily. We have to keep it that way. Part of that job is to provide the technology that the aerospace industry can use in designing their new aircraft. The aerospace plane is a good example of that. I can see that the aerospace plane may be, even in my life time, the really so-called SST of the future. On the other hand, we have to take that first small step in building the experimental plane to do that, and that is well underway.

These are random thoughts, Mr. Stokes, but this gives you some idea that we really have to focus on the future at NASA even though the hard work is immediately ahead of us.

RECRUITMENT OF S&E MINORITIES

Mr. STOKES. I am sure of that.

Let me ask you this. This morning I was particularly struck with the fact that when asked about how well the Agency does in competing against the defense industry and against industry in general, the reply was that NASA does very well in terms of its recruitment of scientists and engineers.

One of the areas where there has been a great concern over the years, both on the part of this Subcommittee and at NASA, has been its recruitment and its ability to bring on women and minorities, and particularly at the upper reaches of the agency, the executive level and so forth.

While you may not be able to answer this for me, I am sure someone here should be able to tell us. In terms of recruitment of minorities and women, how well we are doing, particularly in light of the fact that we are often told as relates to minorities that those who go into science and engineering, where we still have relatively few minorities and blacks, that they are unable to compete oftentimes because of the great demand for them by private industry.

So, I would like to know whether you are having that same type of success with minorities that you are having with regular engineers and scientists.

Dr. FLETCHER. Mr. Stokes, I would like to start answering that question, and I will call on Harriett Jenkins in a minute. She is in charge of that program for us.

I am rather proud of what NASA has done under your prodding when I was here. We really got together and put together what I consider a first class EEO program. I am not sure that is what we still call it.

And we did go out and apply the same kind of enthusiasm and motivation that we applied to the rest of the program to try to bring minorities and women in and put them in responsible positions when they are qualified.

I noticed on my return that there were some people in responsible positions whom I had considered well qualified.

Mr. STOKES. Sure.

Dr. FLETCHER. Also, I had the opportunity to sit on a board with Ms. Eleanor Holmes Norton. I am not sure you know her, but she was here in the Carter Administration.

Mr. STOKES. Oh, yes.

Mrs. BOGGS. Oh, yes.

Dr. JENKINS. Good afternoon, Congressman Stokes. Dr. Fletcher is absolutely correct; NASA has continued to make progress in bringing on board minorities, and also women, although we know that both women and minorities are underrepresented in the science and engineering professions.

We also are not competing very successfully with the private sector. As Bob Nysmith mentioned earlier this morning, we are very, very concerned about the salary differential for entry-level hires, however, we have been able to attract very talented people to NASA.

Our hiring rate for minorities and women has hovered anywhere between 37 and 40 percent of the entry-level hires brought on board in the S&E categories. We feel that is a very, very significant rate.

RECRUITING OF MINORITY ASTRONAUTS

Mr. STOKES. Well, that is a good progress report, and certainly, I am pleased to receive it.

Let me ask you this: As we see, we have seen over the last few years more and more minority astronauts coming into the program, and we now see even Asian-American females coming into the program.

What is the likelihood that we are going to see a black female astronaut in the near future?

Dr. JENKINS. We get asked that question very often, and extraordinary steps have been taken to do focused recruiting and to encourage black females to apply, and we assume that during the year, as we recruit for additional astronauts, that you will see some applying, and successful candidates.

Mr. STOKES. Thank you.

Dr. **Fletcher**. Let me add to that, Mr. Stokes, I can't help but give people a pat on the back when they have done a good job. Harriett Jenkins really deserves a lot of credit for communicating with black organizations and groups, and helping to recruit candidates for the astronaut program who are black.

I would say we really went the extra mile under her jurisdiction, even recruiting Nichele Nicole to help us, an actress who was well-known, and that made a huge difference in the early days.

And I think NASA will continue to do well in the future.

ARIANE

Mr. **Stokes**. That is great. We are very pleased to get that report.

Dr. Fletcher, the French rocket Ariane, often called little sister to the U.S. Shuttle Program, is now the primary launch vehicle available to western nations.

Since you have had to ground Delta and Titan rockets, will Little Sister get all of the dates, or do you expect to lose much business to Ariane?

Dr. **Fletcher**. I would like to first make a few remarks, then turn to Admiral Truly, who is truly on top of the problem.

Obviously, during this period, when we are down, we are going to use all the ELVs there are in the world, wherever they are. Ariane will absorb as much as they can. However, they are wise also, they are not going to build up any expectation that they will have to build down again, so I don't know to what extent they will have to pick up the major part of this burden.

Nevertheless, Ariane is flying, so far, keep your fingers crossed, successfully, and there will be offloading from the shuttle, and our other expendables on to the Ariane, I suspect.

If I am wrong, I am sure Admiral Truly will correct me.

Mr. **Stokes**. Admiral?

Admiral **Truly**. No. I certainly agree. In the short term, we will continue to see owners of satellites that have a requirement during our down time go to other places, and the primary place now to go is to Ariane, and I think in the short term, that is not going to change.

I think that our proper course, however, is one we are on, and that is to strive as hard as we can go to get the shuttle program back into place, and look to other alternatives.

In the last few weeks I have had conversations with businessmen who had to make the difficult decisions as to what to do in looking at our return to flight schedule, and the Ariane opportunities, I have yet to run into the first one, who wanted to move away from the shuttle system, if we already had a commitment with them, and towards the Ariane. In each case where it has been necessary, we have given them every assistance that we could, and told them what our situation was.

MALFUNCTIONS OF TITAN AND DELTA

Mr. **Stokes**. I have just one more question, and the Chairman has been very generous with my time here. With the explosions back to back of both Titan and Delta, have we been able to successfully pinpoint the malfunctions that occurred there, and do we really know all we should know about them?

Dr. Fletcher. Well, Mr. Stokes, the investigations of both of them are still underway, and we interact to some extent with the Titan investigation, but not completely.

We, of course, are familiar with our own investigation of the Delta accident. Dr. Graham and Admiral Truly have both been involved in those.

Would you want to add anything to that?

Dr. Graham. Certainly, I think in the case of the shuttle accident, it is clear that the primary cause was, as you have read, a leaking field joint seal in the solid rocket booster.

There are several possible influences on that seal that could cause it to leak, and our program to redesign that seal is directed not at pinpointing exactly which mechanism caused it, but rather to comprehensively change the design, so that none of the possible ways that a leak can be included in that joint can occur in the future.

In terms of the Delta, we are still at a relatively early stage in that investigation. The telemetry sent back from the rockets shows two large spikes or pulses of electrical current on the main battery bus that operates the first stage engine electronics, the second spike occurs just before the engine begins the shutdown sequence, milliseconds before.

Therefore, circumstantial evidence indicates that that spike, in fact, initiated the shutdown sequence, and it appears from a tentative look, to be consistent with the way the electronics operates.

We don't know yet why the current spike appeared, what caused it, and we are recovering components of the Delta even as we speak, in order to look at those electronic assemblies.

Admiral Truly's people at the Cape have found the boat tail of the Delta, and have found the engine, and are bringing that aboard so that it can be inspected. I think that will add a great deal to our understanding of that particular accident.

Admiral Truly, do you have anything?

Mr. Stokes. Admiral?

Admiral Truly. No, other than that we have had Air Force people on our Challenger board, and are available to the Delta accident, and we have NASA people that are on their Titan Accident Board which is in progress.

But other than what Dr. Graham said, I think that was a good summary of where we are.

Mr. Stokes. Is the prognosis good that we at some time in the near future can get both of these launch vehicles back into circulation?

Admiral Truly. Certainly in the Delta, which is our responsibility, I think that we will pinpoint the location of that electrical short, which apparently, with the information we have now, was what led to the accident itself.

I am very hopeful, as a matter of fact, that sometime this afternoon, we can get that engine and electronics on board and get it ashore. If it has not been under the water for too many days, possibly we will have literally physical evidence of the problem, and soon get back into flight.

We are doing certain testing down at the Cape on the next Delta vehicle to understand some of the electrical characteristics of the system and that is being done under the auspices of the accident investigation board.

So, I am confident that they will quickly conclude, and we can decide whether or not there are hardware changes we need to make to subsequent vehicles, and that will be based on whatever the cause is.

Mr. STOKES. Thank you very much.

Thank you, Mr. Chairman.

Mr. BOLAND. Mr. Lewis?

COMPARATIVE NASA SPENDING

Mr. LEWIS. Mr. Chairman, You are more than kind to me, walking in on the schedule as I did.

Dr. Fletcher, gentlemen, this morning's schedule kept me away, and I know I must have missed a very interesting and worthwhile session.

Mr. Chairman, you are usually very gentle with your Members when they are questioning, but should I get off on tracks that have been covered 10 times, please throw a club my way; I would be happy to receive it.

Mr. BOLAND. If you get off the track, you won't get an answer anyway, so——

Mr. LEWIS. All right.

First, let me express my congratulations to you for your new responsibilities and opportunities.

Dr. FLETCHER. Thank you.

Mr. LEWIS. I have asked my staff, because of questions raised relative to funding of NASA, to do a bit of homework relative to comparative annual spending, over the space program's history.

I would like to probe that. I have a table here prepared by CBO demonstrating that in 1985 dollars, the buying power of the space program during the shuttle years is less than half of what it was while we were in the Apollo years.

At the time of the first Apollo launch, which was 1967, the buying power of about $18 billion compared with $6.3 billion at the time of Columbia's first launch in April 1981.

The table we have that I will be glad to share with you shows a steady continuing decline in NASA's purchasing power; fiscal year 1966 at $18 billion during Apollo, to about $6 billion in fiscal year 1979, when we were two years away from our first shuttle launch.

First, let me ask, did this Committee ever cut funding for the shuttle or NASA overall during those years of steady declines?

Dr. FLETCHER. I am not sure, Mr. Lewis, exactly what cuts were made by this Committee. Most of the recommendations by this Committee were in the nature of rearranging priorities which we did from time to time, and I hope we responded appropriately.

Mr. LEWIS. Must be a new pattern, Mr. Chairman.

Mr. BOLAND. I can answer perhaps better than Dr. Fletcher. As a matter of fact, we increased the budget requests in those years.

Dr. FLETCHER. Thank you, Mr. Chairman.

Well done.

Mr. **Boland**. Now, are you going to dispute that?

Mr. **Newman**. No.

Mr. **Lewis**. I think the record might indicate that any cutting done was done before that.

Mr. **Boland**. It is a significant table, and we appreciate it, and I know that the other side of the table appreciates it, too. That has always been one of the arguments before the Appropriations Committee in the area of constant or continuing dollars—that you always go down.

That is, I guess, probably true.

Mr. **Lewis**. I know you want a fiscal conservative like myself to raise these points.

I think the record will indicate that the cutting done was done before it came to this Committee.

Dr. **Fletcher**. That is completely true. No question about that, Mr. Lewis. Cutting was done by OMB, and I think your figures are approximately correct.

It is my impression, however, that even though it is down by a factor of more than two from the Apollo days, that it went down deeper than that, and is inching up just a little in the last two or three years until this Deficit Reduction Act came up.

That is my impression. I am sure I would be told.

BUDGET CUTS

Mr. **Boland**. Can you outline where the cutting was done?

Dr. **Fletcher**. I can remember two big cuts when I was here at NASA. One was in about the fiscal year 1973 budget. I remember that very well, because we had astronauts on the moon, and we were arguing this question. That was 10 or 15 percent over the level budget we thought we had committed to.

I remember getting some criticism from this group about why we would do such a thing.

Then I think we got another one in either 1974 or 1975, Tommy Newman can correct me, which one was of sufficient size that we had to slip the shuttle program another year and increase the cost.

After that, I don't remember the cuts, but there were cuts here and there in the program during the Carter years.

I think in the last three or four years, those cuts were there, but nevertheless, as I recall it, the budget increased ever so slightly until of course this last year. That is the Deficit Reduction Act cuts that you all know about.

Mr. **Lewis**. I wouldn't want to point any fingers per se. The cuts we're referring to were made over more than one Administration, reflecting bipartisanism.

Dr. **Fletcher**. Yes.

REASON FOR DEVELOPMENT OF THE SHUTTLE

Mr. **Lewis**. What in fact were the reasons for the development of the shuttle? Were they in fact economic?

Dr. **Fletcher**. Well, no, the main reason for the shuttle development—I can respond to that one because I was there when it was in the process of being reviewed by this Committee—was to provide a more routine and easy access to space for men and equipment.

That is to and from space. That was always the object of the shuttle program. You might say improve the state of the art in regard to space transportation.

I think that part has been achieved.

Another reason, although it was not the primary reason, was to make it a more cost-effective transportation to and from space. I think we have done that, also. It is certainly cost-effective in comparison to other transportation systems, as Admiral Truly indicated with respect to Ariane. Even though that was the primary purpose, it was a major purpose, and we spent a lot of time debating on how economical or uneconomical it was over those years.

Mr. LEWIS. Did you yourself ever meet with President Nixon or discuss the shuttle program with him?

Dr. FLETCHER. Yes, indeed, Mr. Lewis, on more than one occasion. In fact I think it was President Nixon and I that announced the shuttle program for the first time in January, I believe, 1972.

Mr. LEWIS. January 5, 1972.

Dr. FLETCHER. All right. Very good.

Mr. LEWIS. Can you tell me first did the President tell you personally what he thought the justifications for going ahead with the program were?

Dr. FLETCHER. Yes, indeed, Mr. Lewis. I cannot go into detail on what the President said, but he indicated that it was a necessary next step in the manned space program, and he especially wanted to make sure that it was for all Americans, that is, the civilian part, scientific part and the military part, which it was at that time.

SOVIET SPACE PROGRAM

Mr. LEWIS. Mr. Chairman, on another line of questioning, I have had brought to my attention a good deal of information in recent weeks relative to what the Soviets may or may not be doing in this whole field.

At the risk of raising a flag that the Russians are coming, I am very interested in having the record indicate the problems that in your opinion we may face there.

Would you give us some indication of where we are in terms of the Soviets program?

Dr. FLETCHER. Mr. Lewis, I can give a sketch of where I think the Russians are. Obviously a lot more can be said in a more classified arena but I think there is plenty of information in the open arena that we can discuss.

They, of course, have built a Space Station, a permanent presence in space in their new Mir vehicle. It is a laboratory much smaller than the Skylab that we must have flown in about 1974 or there about, but nevertheless with longer duration.

People can stay there up to a year at a time. So in terms of the biological effects and so forth, we get all of our information on the long-term effects about people from them.

They also have plans underway for a kind of a space shuttle and there are several versions of that, some of which have appeared in the newspapers. I think they realize that a transportation system is also necessary if you are going to have a permanent presence in space, and they are rapidly trying to catch up in that area.

I have no idea of the dates anticipated for theirs. I don't know what they call it, an aerospace plane, or a shuttle.

Mr. **Lewis**. A shuttle, yes.

Dr. **Fletcher**. They probably have a Russian name for it.

In addition to that, it is likely that they will try to move in the direction of a larger lifting vehicle, and I have no idea of what that will be. As you know, they abandoned for a while their attempts to go to the Moon because they didn't have the Saturn V that we had, that is what allowed us to go to the Moon and back again.

I imagine they are working hard on that aspect of the program.

So they are moving ahead on a steady pace in the manned space arena.

Having said that, I think they are beginning to become interested in the science area. They were way behind in the science area for many years, and we were doing all the science in space, we landed on Mars, we sent the Voyager to the outer planets and so on.

They are beginning to become very active in the space science arena and the best example I can think of is their recent voyage to the Halley's Comet, which even had U.S. investigators aboard.

So I think they are catching up rapidly in the science area as well. I am sure they are doing things in aeronautics but I assume your question was directed to their space program.

SOVIET LAUNCH VEHICLES

Mr. **Lewis**. Yes.

Can you tell us for the record, is there significant evidence or concern about the Soviets work effectively impacting our market in other countries?

Dr. **Fletcher**. Mr. Lewis, that is a recent thrust on their part, and I am not entirely on top of that except from what I have read in the paper. They seem to be indicating that, especially since the accident that they are ready and willing to help out, quote unquote, in the launching of other people's satellites.

Mr. **Lewis**. I am thinking of their offer to the Japanese, for example.

Dr. **Fletcher**. Yes. I would rather have somebody else comment on that, because I am only familiar with the newspaper accounts.

Mr. **Lewis**. That is all I have, too.

Dr. **Fletcher**. Admiral Truly?

Admiral **Truly**. Your question is a good one having to do with the potential viability of a Soviet system to launch satellites, and I don't have any specific information about that. I do know that if they develop a viable system they tend to mass produce and do it well. I would expect that they would be putting a great deal of resources into any new area in space that they were moving into. That has been their history.

Dr. **Fletcher**. Mr. Lewis, Ike Gillam is in charge of NASA's commercialization work and because of that responsibility has been following the ELV programs internationally as well. I would like him to also respond.

Mr. **Gillam**. About 18 months or two years ago, the Soviets made an offer to Inmarsat to launch the Inmarsat series of satellites that they were planning, on the Soviet Proton vehicle. That was their first entry into the market offering launch services on a commercial basis.

Since that time, they have continued their interest, but I do not know of a second public offer that they have made since they made the offer to Inmarsat. That was for a launch at about $25 million per satellite.

Mr. **Culbertson**. More recently the Soviets have published information on the commercial value of their materials processing work that they have been doing in space and for the first time I have seen them talk about profit and return on investment in an interesting sort of way, first time in that part of their space program.

SOVIETS MATERIAL PROCESSING

Mr. **Lewis**. Great, to say the least.

What do we or don't we know about the 1600 materials processing experiments conducted on their stations.

Mr. **Culbertson**. That is what I was referring to.

Burt, do you know any more detail about that?

Dr. **Edelson**. I don't have the details on that. They have conducted a number of crystal growing experiments on their Salyut and more recently on their Mir Space Station. The results that they published have not been as significant as our results on Spacelab. Nevertheless, they are making strides in this area. They are obviously mounting a program in materials processing in space, and have offered opportunities to a number of European countries to participate in their materials processing in space program on their Mir Space Station.

Mr. **Lewis**. Mr. Chairman, I know this subject area is not one that should or will be dominating our discussion here, but nonetheless it is an interesting area of consideration that the Committee ought to be aware of, and we all should be of what the Soviets' interest is in space, the effect of their program in order to try to measure that relative to our own priorities.

You have been more than generous with my time, Mr. Chairman. I appreciate it.

Mr. **Boland**. Thank you.

Mrs. Boggs.

BOGGS' INTRODUCTORY

Mrs. **Boggs**. Thank you, Mr. Chairman.

Dr. Fletcher, all of you, thank you very much for your full and complete testimony.

Thank you especially for recognizing that we must recommit ourselves to the goal of maintaining leadership in space. At this point we really have to show that we have the courage and vision and determination to continue our commitment, or else we will lose our leadership position.

I would like to comment just a little bit on some of the uses of the experiments from space and the development from space that perhaps were not mentioned earlier and I think that the great breakthroughs in medical technology are something that has benefitted all of the peoples of the world.

Communications we know have been revolutionized but we have also revolutionized nearly everything else in the world—whether in industry or commerce, the way we live, the way we communicate with each other, or the miniaturization of computers.

Now we are going to see the great results of the supercomputers that will add another level of revolution to the way that we live and operate on the planet Earth, and on, perhaps, other planets as well.

I would like also to commend the program for its search and rescue operations and for the continuance of that program, despite the difficulties that have been endured through the Challenger accident.

This is an international cooperative effort that we must pursue, as we continue to pursue other international cooperation efforts.

I am really pleased to hear you, Dr. Fletcher, say that the Space Station Program is so vital to our international cooperative efforts. In your full testimony you say that the development of the Space Station in fiscal year 1987 will signal to our international partners that the U.S. commitment to the Space Station is firm and that their own budgetary and intellectual resources can safely and productively be devoted to a cooperative Space Station Program.

That is very consoling to all of us, I think, on this Committee.

Dr. **Fletcher**. I expect your support on that regard as well, because I think it is important, too.

Mrs. **Boggs**. I have been a very strong supporter of manned Space Stations for a very long time. I was encouraged the other day to have had appearing before our Committee a young student from Georgetown University where they are already teaching international relations in space, and I think that the humanizing of space is something the United States has done extraordinarily well, and it could be the leader in the new frontier that is space in implementation of the Space Station Program.

SPACE STATION BUDGET REQUEST

I would like to ask Mr. Hodge what the special plans are for implementing the Space Station Program in this fiscal year.

Mr. **Hodge**. This is for fiscal year 1987?

Mrs. **Boggs**. Yes.

Mr. **Hodge**. We have asked for $410 million, $250 million of which is to complete the definition phase of the program. About half of that money is going to the contractors who are doing the work, and about half is going to the technology part of the program.

The other $150 million is to begin the development phase, the hardware starts and of that $150 million, $19 million is going to the contractors who actually build the Space Station.

Thirty million dollars is to get software programs started. Thirty million dollars is to start the system engineering for the final design of the system.

That is essentially the way we are breaking down the $410 million.

SPACE STATION—INTERNATIONAL COMMITMENTS

Mrs. **Boggs.** Is that sufficient for pushing the program forward to meet our international commitments as well as to our own people and our own industries?

Mr. **Hodge.** Yes, the $260 million is what we have asked for to complete the definition phase of the program; it is very important we do complete it to the level that we have set. The $150 million is vital to get the hardware program started, both for a number of reasons, one to keep pace with our international partners; the other one is to allow our contractors to understand which ones will win and which ones are going to lose, so that they can either move out with the program with us or go off and do whatever else they want to do.

TOPEX

Mrs. **Boggs.** Thank you very much for that information.

Another international interest I have is TOPEX, ocean topography experiment. It is not only interesting to scientists but to the users of ocean data as well. Is that going to go forward in this year's budget considerations?

Dr. **Fletcher.** I can say yes. Of course the TOPEX is a follow-on to an earlier program that we had called SEASAT and I think it is an essential step forward. I think Burt Edelson probably should comment further on it. I think it is going smoothly, is it not, Burt?

Dr. **Edelson.** Yes, we have asked for a new start authority for TOPEX in the fiscal year 1987 budget. This is a high precision altimetry experiment that will very precisely measure the ocean height and thereby give us information on world ocean circulation. It is in fact an international project that we are doing jointly with France and part of a worldwide international program called WOCE, the World Ocean Circulation Experiment.

So it is looked upon throughout the world as the significant next step forward in oceanography.

Mrs. **Boggs.** Did the discovery of the geysers have anything to do with that program in the Atlantic?

Dr. **Edelson.** I don't think so, specifically, since that is what meteorologists call a local area phenomenon. But it will give us sort of a view of ocean circulation.

Mrs. **Boggs.** Thank you.

Thank you, Mr. Chairman. Thank you, Dr. Fletcher, and all of you.

Mr. **Boland.** Mr. Boner.

BONER'S INTRODUCTORY

Mr. **Boner.** Thank you, Mr. Chairman.

Dr. Fletcher, I know I join with the other Members in welcoming you before us. I should say your appearance but this is your reappearance as the Administrator. Needless to say, you come at a time when it is very critical to the national program and my colleagues and I are anxious to see the NASA program proceed and are interested to see the entire program reestablish its goals, re-define its objectives, and go forward with the future exploration of space.

Last Friday I had astronaut Rhea Seddon visit with me in the Fifth District of Tennessee. We met with AVCO Aerospace, with schools and civic clubs, and you should appreciate knowing that there is a strong groundswell of support for seeing the space program continue and a real concern with the safety of those who are involved.

I know there is a great deal to learn from the investigations of both the shuttle and the Titan explosions and I imagine you are finding that there is a great deal to learn about management of the NASA program.

I hope that as we work together with you that you will be able to call upon our staff and this Committee to be of assistance. I would like to ask a couple questions that relate to the shuttle itself.

SPACE STATION SCHEDULE

The President in 1984 said that we would try to establish a Space Station within a decade. Now, with the delay in the flights to July 1987, what will the impact be on aspects of that space program, such as the completion of Phase C and D?

Dr. FLETCHER. Well, I would like to start with that, Mr. Boner, and say that as near as I can tell the accident really didn't have any technical impact on the move toward the Space Station in 1994.

The only impact that could conceivably be there, which is recognizable anyway, could be a budgetary impact. I am hoping that we won't let the budgetary impacts influence that date because that is a pretty sacred date since the President has already announced it.

As far as I am concerned, a supplemental appropriation ought to be able to take care of whatever is required to fix the space shuttle. The Space Station ought to be allowed to go on, as John Hodge has indicated, according to the schedule outlined for you last year and just now.

But if John wants to modify that in any way, feel free.

Mr. BONER. If I may rephrase what you are saying then, that you don't see a delay in the efforts to establish a Space Station at the target date of 1994, you don't see that delayed as a result of this?

Dr. FLETCHER. Not unless there is budgetary impact of some kind, and I am really not familiar with all the rules and regulations involved in the Deficit Reduction Act, so I cannot be sure of that.

But technically, no.

Mr. BONER. It is my understanding that Phase A and B have pretty much been completed and we are now into C and D. What is the status of those two phases?

Mr. HODGE. Our Phase B started with a 21 month schedule, we have completed one year. Phase B officially ends the end of January. We are presently putting together our request for proposals. We will be able to issue those providing we get the funding to do so on October 1 of this year. That will allow us to bring the hardware contractors on board around the first of May next year.

Mr. BONER. So when you say the first of May of 1987, you will then have determined who the contractors are going to be and what part of the Space Station they will be producing?

Mr. **Hodge**. Yes, and in parallel with that we are beginning our negotiations with our international partners to have a firm understanding with them by the beginning of next year on what pieces they will do.

REPLACEMENT ORBITER

Mr. **Boner**. Dr. Fletcher, with the destruction of one of our vehicles in the shuttle program, we have three now, I believe, and if the Enterprise has not been used previously, you are looking at two that are usable if we wanted to immediately?

Dr. **Fletcher**. The Enterprise is not one of the three. The Enterprise is not a flying machine at this time.

Mr. **Boner**. So we have three left.

Dr. **Fletcher**. Three left in addition to the Enterprise which only flew off the back of a 747.

Mr. **Boner**. What do you see at this point in time in recommending that additional funds be set aside to build another vehicle?

Dr. **Fletcher**. Yes, indeed we need that replacement orbiter desperately.

Mr. **Boner**. What is the cost of an orbiter?

Dr. **Fletcher**. I will have to turn to Admiral Truly.

Admiral **Truly**. Two billion dollars.

Mr. **Boner**. Are there many changes that you will want to make in the next one being built? Are there any technological advancements that you would incorporate into the next one?

Admiral **Truly**. No, we would rebuild it with the changes that have evolved in the shuttle system formally that are now being retrofitted into some of the others. It would be built to an up-to-date design but the dollar cost estimate would build essentially a carbon copy of the vehicle we most recently constructed.

Dr. **Fletcher**. Could I interrupt? There is always a problem with engineers because they always want to make things a little better than they used to be. So Admiral Truly and myself and all of us will have to be careful there are not too many changes other than those planned for the other shuttle.

Mr. **Newman**. Perhaps we should explain that figure a little more. Our number of $2 billion assumes that we use the set of structural spares that have been under production for some time. It would require an additional $450 million if we replace the structural spares.

ASTRONAUTS RECRUITMENT

Mr. **Boner**. What about the pool of astronauts? Do you feel you have enough in your pool; are you recruiting others? What is the status and what is the need?

Admiral **Truly**. We have I think eighty or ninety men and women in the Astronaut Office in Houston today. In recent years we have gone to a procedure of having an annual selection of a few astronauts rather than every three to five years bringing in 25 or 30.

We have an annual selection that had been started prior to the accident, and in talking to the people in Houston and in the Astronaut Office to make that selection has proceeded incidentally to the point where we have narrowed it to the people that would be brought to Houston to be interviewed.

I am presently debating that issue now to decide whether or not to continue this selection and then bring those people on board perhaps the middle of 1987 or to just terminate this selection and redo it in 1987. I think certainly by 1987 we will want to get a small number of people on board.

That is a much more manageable way to handle the office.

PROJECTED LAUNCHES PER YEAR

Mr. **Boner**. Prior to the fatal accident that occurred, what was your projection of how many launches per year you wanted to make?

Admiral **Truly**. If I remember correctly, we had 15 launches scheduled this year, building to a launch rate of 24 per year with a fleet of 4 orbiters.

Mr. **Boner**. I have had a concern expressed by some in the program that if you were to go to the 24 launches a year, which you were shooting at, that there were a lot of problems with the limited number of astronauts being overworked, and recycling of the equipment to be used. Assuming that you go back, that you are able to start back up in July 1987, what will be your goal as you reevaluate what you want to accomplish and how many flights you want to launch?

Admiral **Truly**. We have put into place as a part of our efforts to get back to safe and sustainable flight—an effort to reevaluate the rates that we think are reasonable with the orbiters that we have, and the crews and also with the very detailed look, not only at crew training and delivery of products such as checklists and software, but also work shifting at the Cape. In looking at our historical record and in reviewing the early results is quite a bit of work, and we are sort of in midstream. I have briefed Dr. Fletcher. We have not laid out a final manifest, but with the 3 orbiter fleet we should be able to probably in the first 12 months get 6 to 7 flights, as I spoke about earlier, the second year 9 to 11 flights, and a sustainable rate of 12 to 15 flights with 3 orbiters. These goals depend mostly on the complexity of the payloads and the workflows to deliver the right vehicle to the pad with the right payload so that those numbers are smaller. My recommendation is that these are more reasonable rates than would be achievable and they are smaller than they were prior to this intensive review.

Mr. **Boner**. How do you break down the cost of a launch if you don't count the personnel involved, but the hard dollars that are spent to launch. What do you generally have a cost figure of?

Dr. **Fletcher**. I think Mr. Newman has that.

Mr. **Boland**. May I interrupt a bit? We have a number of questions with respect to the costs of ELVs and the shuttle and the cost of each launch. I would like to keep that together for when we get to that particular area.

SUPPLEMENTAL

Mr. **Boner**. Okay.

Considerable attention has been paid to and mention has been made of the fact that Congress has increased some of the request for the NASA program. Will you be able to get OMB approval on your request, or will we have to add on to that request?

Dr. FLETCHER. That is an awfully good question, Mr. Boner, and I have made predictions in the past that have been wrong, and so I would hesitate to make a prediction of how well it is going to come out of the White House.

But let me say it is not just OMB, but it is the President himself that makes those decisions.

I am hopeful that we can come up with a supplemental that will not require any increase by this Committee or any other Committee of Congress, but I don't want to say I predict that that will happen.

ACTS

Mr. BONER. What do you see for the future of the advanced communications technology satellite? I understand you requested $119 million from OMB and they provided nothing.

What will be your position on that?

Dr. FLETCHER. Well, from my point of view, I think that is an extremely useful program. I think it is time that we were retaking the lead from industry, industry has not put up advanced communications satellites.

They have more success to the kinds of satellites that they were building, although small improvements were made back 10 or 15 years ago.

So, it was a timely thing to do. On the other hand, when you have a budget limit, some things have to drop by the wayside, and that particular program was unable to be fit into the fiscal year 1987 budget.

I am sure Burt Edelson will have a different perspective on that, however.

Burt, why don't you respond?

Dr. EDELSON. My perspective is essentially the same. I think that it is very valuable, and the technology is important and essential for our country to maintain its technological leadership in this important field of satellite communications.

However, the issue raised by the Administration is whether such a program should be supported by the private sector. So, it is not really a question of the value of the technology or the program, but whether it should be financed by the government or the private sector.

QUALITY ASSURANCE PERSONNEL

Mr. BONER. Last week, before a hearing on the Senate Commerce Subcommittee, Senator Gore, the junior Senator from Tennessee, revealed that the number of NASA quality assurance personnel has dropped from 71 percent since 1970.

I realize that percentages are oftentimes deceiving. I would like to know whether you believe there are currently enough quality assurance personnel on NASA payrolls and if not, what kind of increase above the current personnel levels is needed?

Dr. **Fletcher**. Mr. Boner, that is just an awfully good question.

Mr. **Boland**. That question was asked this morning, too.

Dr. **Fletcher**. Yes, it was. Do you want me to respond again, Mr. Chairman?

Mr. **Boner**. I was here this morning, but I don't remember you giving a figure about that. I know we made reference to it.

Dr. **Fletcher**. Let me quickly deal with it. Quality control is just extremely important to an effective operation of not only the space shuttle, but all of our programs.

The apparent decrease of quality control personnel, advertised in the press recently, is primarily caused by two major things, mainly the removal from an in-house production capability from the Goddard Space Flight Center and from the Marshall Space Flight Center.

Those two centers used to build things in-house, the Explorers at Goddard and the early Saturns at Marshall.

So that was the major cause of the drop in personnel at those two places. In other cases, there was reduction of personnel because of transfer of responsibility in quality control over to other agencies, the AFPROs and DCAs, Defense Department agencies.

I think quite frankly that that whole thing needs to be looked at again, because quality control is an essential part of what Dick Truly is doing now, and what we need to do on the rest of our programs, and we really have to rethink that one through again.

PROCUREMENT PRACTICES

Mr. **Boner**. One other question, and then I will stop, Mr. Chairman. This relates to your procurement practices and how efficiently the taxpayers' dollars are being spent.

Do you operate under the same rules and regulations that the Defense Department does? Are you evaluating your procurement procedures to see where you can save money, and if so, what are you doing in these areas?

Dr. **Fletcher**. Well, Mr. Boner, I can say that from my knowledge, we do at least as well as the Defense Department. For one thing, we are a smaller agency.

Mr. **Boland**. That is not saying much.

Dr. **Fletcher**. For one thing, we are a smaller agency, and we can control things a little better.

We work very closely with the Inspector General and with the General Accounting Office and really, our overruns on major projects have not been large.

There have been two or three major overruns in the last 15 years which are noticeable, and there is good reason for each of them, which you may want to go into.

Whatever is the case, we really think that we manage our programs well, but we are going to do it better in the future.

Jack O'Brien, do you want to answer?

Mr. **O'Brien**. Yes, both the Department of Defense and NASA are subject to precisely the same procurement procedural statutes and the same Federal acquisition regulations apply to both of us.

Mr. **Boner**. Thank you, Mr. Chairman.

BUDGET HISTORY OF SHUTTLE

Mr. **Boland**. Thank you, Bill.

Let me say that with respect to whether or not the budget itself has been cut, in 1977 this Committee added $95 million to the shuttle. Then, in 1980, there was a request for $100 million in the supplemental, which we provided. The hearings at that time also indicate that this Committee indicated that there was a need for an additional $100 million in that supplemental; that particular opinion was agreed to by Mr. Yardley.

So, then, in 1982 and 1983, we added $50 million in the Jobs Bill, and another $50 million in 1983—all to the shuttle program.

One of the problems, of course, is that they were transferring funds within that particular program, and as there was a slippage in the program itself, the request for funding was not as great.

Is that a fair statement, Tom?

Mr. **Newman**. The early requirements were not as great as it was after the program was delayed; that is right. The reductions referred to in the letter to Senator Gore dealt with reductions that had been taken in the early part of the program from the request we made to the OMB.

There were reductions in fiscal year 1983 and fiscal year 1984 and——

Mr. **Boland**. But those reductions were the result of——

Mr. **Newman**. Of the OMB review. I think your statement is basically correct.

Mr. **Boland**. Let me also indicate that I think a few years ago, we had some discussion over spare parts, and that there was no necessity for acquiring additional spare parts in that year.

In looking further at the hearings, back in 1983, Mr. Beggs indicated that our flexibility was gone. The consequence of that was that we didn't buy a lot of things early, which we could have bought at a lower cost, and probably would have saved us money at a later date.

And we were willing to provide for additional spare parts back in those early years. That is another indication that this Committee really supported the shuttle program.

I don't think anybody in the room could disagree with that. Let me ask you a question, Dr. Fletcher, with reference to the management review that will be conducted by Sam Phillips and will be completed in a period of six to eight months, I think you said this morning. That is a long period of time. The problem is now. The management problem is now, isn't it?

Dr. **Fletcher**. Yes, sir.

PHILLIPS MANAGEMENT REVIEW

Mr. **Boland**. Why do we have to wait that period of time? I, myself, might have some difficulty, and I expect only for myself, but I would have difficulty funding any new starts in the NASA budget unless we can solve that problem in a very short period of time.

Dr. **Fletcher**. Mr. Chairman, there are two——

Mr. **Boland**. Why does a management review have to take that long when you can look at some of the problems that have developed as a result of some of the management problems in the centers?

Why does it take that long?

Dr. **Fletcher**. Mr. Chairman, there are two or three aspects of the answer to that question. One is the management of the space shuttle program.

That will go on by Admiral Truly right away, and will not take that long. That is our immediate problem. The other management question will be the management of the Space Station.

That also is a time-urgent problem. That will be done, hopefully, in a timely fashion.

Mr. **Boland**. I wouldn't disagree with that because that will be a big problem, and a very costly one. I think it has to be looked at closely.

Dr. **Fletcher**. What General Phillips is doing is taking a broader, in-depth look at the whole situation at NASA, what has happened since the Apollo days. He was there then. This means taking an in-depth look into interpersonal relationships, quality of the people and so on. This is really a broader look and hopefully will provide for the next 10 or 15 years.

That kind of a review is going to take longer. It is part of the old adage if you are going to make changes, structural changes in an agency you want to measure twice, and saw once, I guess that is the way to say it.

That is what I hope that General Phillips plans to do. By the way, I think it might be advisable some time to ask General Phillips to come in and brief you on what his plans are once he gets established.

APOLLO ERA

Mr. **Boland**. We would be glad to have it. It is difficult to compare, of course, the Apollo days, which really were the halcyon days, the glory days—everybody was in it, everybody was proud, you were really moving ahead, and you spent all the money in the world. Whatever you wanted, you got.

And it was a program that was, I guess, completed on time, and within budget, as I recall—some $20 billion, that is what the record shows at least.

But that particular feeling is not there any longer, is it?

Dr. **Fletcher**. No, it will never be the same, because the landing on the moon, Mr. Chairman, is a pretty hard act to follow.

Mr. **Boland**. You bet.

Dr. **Fletcher**. On the other hand, some of the excitement is still there. The young folks coming into NASA are very excited about the things going on. They are very excited about the space shuttle program.

They are looking to the Space Station as the next step in space. They are really excited when we fly unmanned space craft way out to the outer planets, which they just barely heard about in their high school classes. We think there is a lot of excitement there, and these people need to be motivated and dedicated, and part of the business getting Admiral Truly's shop back on track is to make sure all the people at NASA are properly dedicated and motivated.

LAUNCH AND SCHEDULE PRESSURE

Mr. **Boland**. This morning, Admiral Truly, I think you indicated that the NASA engineers missed the problem on the solid rocket boosters, and also indicated that maybe they missed the significance of it, too.

The problem, I think, also can be attributed to the pressure being exerted upon NASA at that time, to launch. It has to be said, some of the NASA personnel have said they didn't believe NASA was really under pressure. I really don't think that is right when you look at the whole scenario. In my judgment, there was a very strong, yet subtle pressure to keep the shuttle operating. The problem with the SRB joint was known in NASA at the Marshall level, and probably at Headquarters. I suspect that the problem was known, and no one in the organization wanted to come forward and say, "Look, this problem is serious, we need to fix it, and we will have to stop launching for nine months."

I don't think anyone really wanted to say that because in many ways a nine-month shutdown of the system, when you are looking at a launch schedule for calendar 1986 of 15 or 16 flights, when you are looking at launching the two most complex missions ever flown on the shuttle, Galileo and Ulysses missions, when you are looking in the teeth of a very serious challenge by Ariane, and the Air Force wanting to go back to the expendables, a nine-month delay would have had, at least in my judgment, a disastrous impact upon the program.

Is that a fair statement?

Admiral **Truly**. I think within the program, a nine-month delay would certainly have raised a hue and cry from the many customers of the system and I must tell you that I agree with you.

In my personal experience in this space business, both in NASA and before then, in the MOL program in the sixties, and in the Navy in the interim, before coming back here, there is pressure in the system.

Mr. **Boland**. You can't get away from it.

Admiral **Truly**. It exists in the ELV industry as well as the manned industry. My personal feeling is that in this specific case, there were signs of a problem that engineers did find. Somehow the system failed in recognizing the magnitude of the problem and the required testing, that we have now done post-accident, was not accomplished.

Whether that was due to "schedule pressure" or not, I don't know. I somewhat doubt it. Frankly, this is not the first safety problem that has ever been bubbled up in this system, and once it was addressed properly, I think the system has responded.

If you remember, prior to the first flight, there was tremendous pressure to get started and yet, we had a major engine development program going on at that time. We had a number of incidents in tests, ground tests, which is where you want to have them, and we delayed until they were solved. Same way with the thermal protection system.

But in this case, I can't answer your question. I don't know whether launch pressure had something to do with it or not. I do know that the system failed, and we are going to do everything that is humanly possible to correct it.

OVERFLOW OF PAPERWORK

Mr. **Boland**. Oh, I think you will. I have a feeling this may be one of the points that the Rogers Commission will probably touch on.

Let me ask you another question with reference to impact. I get the impression that there is a lot of paperwork that really grounds the agency at times. Is this correct? Are you surfeited with a lot of paperwork?

Dr. **Fletcher**. I will start with this. There are two kinds of paperwork: useful paperwork and not-so-useful paperwork.

On the business of a decision to launch, a lot of that signoff is absolutely necessary, whether it is done on paper or whether it is done on a terminal or whatever.

You really need to have everybody that is involved to make sure that he believes it is ready to go. This includes the third tier contractors I mentioned earlier. That kind of paperwork is necessary.

Mr. **Boland**. It is necessary if they read the papers, that is correct.

Dr. **Fletcher**. But there is probably a lot of other paperwork floating around NASA that probably could be reduced and that is something we need to look at again.

Admiral Truly, you may want to comment.

Admiral **Truly**. I guess my objection is that during my time in the shuttle program there are tremendous competing problems.

You have an absolute requirement for documentation, to understand the hardware that you have, its pedigree, from the time we had a requirement to design it, to build it, qualify it, test it, and fly it. And you need a trail of direction.

On the other hand, when you build that trail, you can build a monumental human task to keep up with it.

One of the things that we are going to attempt—and, frankly, I think it is one of the hardest jobs we will have in this system during this downtime—is to take a look at the efficiency of this required paper trail and see if there are not ways that we can reduce it without losing the essence of it. That is beginning to be very, very tough to do.

OVERSELLING OF THE SHUTTLE

Mr. **Boland**. Let me ask you, Dr. Fletcher, this gets to the question of whether or not the shuttle has been oversold.

When one reads the hearings of this Subcommittee probably nine or ten years ago, one could easily get the impression that the shuttle was oversold.

What would be your belief?

Dr. **Fletcher**. At the time I was here before as Administrator, I am the first to admit I am not the world's best salesman, I was trying to present to you what I thought was an appropriate program for this Nation to follow as the next step in moving out into space, which was the space shuttle program.

It was not only the next logical thing to do, but it was slated to be within our then-level budget, and I think we did achieve that goal.

When people talk about overselling, I am not sure what they mean by it. I suspect they are talking about economics of the program. Economics of the program were very carefully done.

We had a lot of external advice, corporations that knew how to deal with mission models, other companies that were experts in economics, and so forth.

The Air Force was involved. The intelligence community was involved. The private sector was involved. Of course, they were guessing what kind of commercial flights there were. I think we presented the program as honestly as we knew how in those days.

Mr. **BOLAND**. I am wondering whether or not you might have been too honest and overblown the program too much. The indication at that time was that the original mission model would hit around 576 flights, and I have the impression that that sounded great in those days, too.

But as you look back at the hearings, I think you have to come up with a conclusion that that was grossly inflated in order to make the economics work.

Dr. **FLETCHER**. Mr. Chairman, it is clear that the numbers were too high.

Of course, I don't like the word "grossly," but nevertheless, they were too high.

I can guarantee that they were not developed in order to make the costs look cost effective.

That was not the purpose of that exercise. The purpose of the exercise was only to show that, in addition to moving out into space, it did satisfy the economic hurdles that people expected for a cost effective shuttle system.

By the way, I think it is still cost effective. It is not just shuttle costs increasing or the number of flights decreasing; all the competitive systems had the same problem. So, it is still cost effective.

ELV'S VS. SPACE SHUTTLE

Mr. **BOLAND**. Well, at that time I think we were left with the clear impression that the shuttle would eliminate all expendable launch vehicles for both NASA and the DOD.

That is correct, isn't it?

Dr. **FLETCHER**. That impression was definitely left with you, Mr. Chairman, and I suspect at this point that was clearly in error.

Mr. **BOLAND**. Just let me read from one hearing as a matter of fact, just to be sure we both agree with what was being said. Let me refer to an exchange between Mr. Coughlin and yourself and Dr. Lovelace in 1977.

I know we are going back in history a bit, but this Committee and the Congress faces a very serious decision here with respect to the Space Station.

We want to be sure that what was said about the shuttle, in all of its value, total value, economic viability, and its importance too—I have said it before and I will say it again. You are not going to operate a space transportation system without a viable shuttle.

I know that. You will never be able to operate a Space Station without the shuttle. I am convinced of that. I don't think anybody else is not convinced of that.

But we have to be sure of the figures and the money that is required for programs that are as large as this. We don't want to run into another problem down the pike four or five years, or into the 1990's, when the Space Station is operating.

John Yardley is talking, and he says,

> The problem is that when you operate two separate systems, expendables and reusable shuttles, the total cost increases dramatically and each user has to pay more.

This is Mr. Coughlin now.

> On the DOD question, what percentage of DOD launches will you be handling with the shuttle?
>
> Dr. FLETCHER. "One hundred percent."
>
> Dr. LOVELACE. "One hundred percent with a five orbiter fleet and two launch sites."
>
> Mr. COUGHLIN. "So once this is proven, they would not need any back-up for their purposes in terms of expendables?"
>
> Dr. LOVELACE. "That is where the national savings come from, standing down the production in the launch capabilities of expendable launch vehicles systems that are in existence."
>
> Mr. COUGHLIN. "But as you see it, DOD, once this is proven, will not be coming to the Congress and saying, 'Now we have to have our own launch capability.'"
>
> Mr. YARDLEY. "They may come and they say they want their own orbiter."
>
> Dr. FLETCHER. "They may want to buy additional orbiters. Ultimately we think that a five orbiter fleet may be too small. Seven may be a more reasonable number but they can't guarantee payloads for seven. But I think they will not come back to you and ask for money for expendable launchers. That is the main point."
>
> Mr. COUGHLIN. "In other words, there is no DOD requirement that is foreseen at the present time that will require another kind of expendable launcher in addition to the shuttle?"
>
> Dr. FLETCHER. "That is correct, Mr. Coughlin."

I don't think there is any doubt that was left in the Committee's minds about what that position of NASA was, and what the concept and rationale of the shuttle was.

So, do you still believe that a shuttle-only system is the least expensive and makes the most sense?

Dr. FLETCHER. Mr. Chairman, I was refreshed during the day or two that I had before coming to NASA on that episode. Remember, we were talking about a five orbiter fleet then, and it would have been better had we got five orbiters in retrospect.

That is easy to say, but with budget cuts and what have you, we were reduced to a four orbiter fleet, which changed that picture somewhat.

Since that time, it became apparent that because of the emergency requirements mentioned earlier by the Defense Department, they had a need for their own expendables.

I think the number was two per year or something of that sort. I think later Mr. Beggs indicated that he would go along with that because they did indeed have a requirement.

However, at this point, the reason I said the earlier statement was in error, is that we have a three orbiter fleet and we are going to stand down for a period of 18 months.

It is clear that ELVs on a much larger scale during this period are going to be required.

It is hard to see ultimately how things will end up, whether we end up with just a few expendable launch vehicles, or whether we end up with more orbiters.

It is easy to say for the next several years it is going to be largely ELVs that take up the slack and some of those may very well be Defense Department ELVs.

COMMERCIAL SATELLITE PAYLOADS

Mr. **Boland**. Dr. Graham, you issued a memo directing the shuttle office not to accept any additional orders for commercial satellite payloads.

In the Committee's letter to you concerning the 1986 operating plan, we recognized your memo and at the same time urged that the shuttle not be prevented for flying commercial satellites when it gets back to an operational status.

What is your view, Dr. Fletcher, on this issue?

Dr. **Fletcher**. Well, we have——

Dr. **Graham**. May I add one point for the record?

First, the memo I effected was directed at our inability to provide a specific launch date for the Skynet-4C satellite at the time that they were in the end of their negotiations for launch services.

There was a phrase in the initial draft of the memo that I believe was corrected in the form that was sent over to the Hill which did not direct termination of commercial services, but only establishes that there was at that time, which I believe was in February, an uncertainty in our ability to make specific launch date commitments and that we would try to work with our customers and accommodate them as best we could within the uncertainty we were facing then, and to some degree are still facing, on manifest dates we can provide.

Mr. **Boland**. I presume that would be your answer, too?

Dr. **Fletcher**. Yes, Mr. Chairman.

I would also like to clear up one thing there.

When we, back in those days, indicated that the shuttle could take up all the slack of ELVs, I don't think we were being misleading, because I think it still could come true.

If you are looking at the most cost-effective way to move to and from orbit, it might still turn out to be a five orbiter fleet.

Remember, though, that the Defense Department has since come up and properly so, with emergency requirements.

That doesn't mean it will be more cost effective. It means that you are going to have to increase the overall cost of the fleet in order to take care of their emergency needs.

So, the statement made back in those days, except for the accident problem, may still stand.

Mr. **Boland**. What about pricing?

Dr. **Graham**. May I make one more comment?

The thrust of that memo—and I believe the policy since then, Dr. Fletcher supports this, as well—has been to provide in the future a launch service capability that is U.S.-based and that is competitive with the foreign launch service providers. The U.S. Service will provide a diverse enough base of launch services so that our own satellite customers—people who need to have orbiter launch services—can't be left in a position of where there are too few resources available within the U.S. to provide a substantial part of their launch needs.

The shuttle, of course, has provided this in the past. As we go into the future, certainly in the foreseeable future, there will be a backlog of launch requirements from the DOD, the scientific and the commercial community.

The use of domestic ELVs to help remove that backlog in the near future is an assumption that we should keep very much in force as we work out the policy of the space launch services.

SHUTTLE PRICING

Mr. **BOLAND**. Let me ask about the shuttle price.

Last year, the price was tagged at $74 million through the 1989, 1990, and 1991 period.

Should we keep it at that? Should it be increased?

Dr. **FLETCHER**. I would turn to Mr. Newman for that one.

Mr. **NEWMAN**. That cost is based on the 24 per year flight rate, the average cost during that period.

For those customers that have signed agreements, I would think we would retain that price. It was also said, as you remember, to make it competitive with the Ariane in that context.

So, I think I would have to consider the position we want to be in in the international market as well as the availability of launches.

Mr. **BOLAND**. Okay.

We will go vote and be back.

[Recess.]

SPACE STATION

Mr. **BOLAND**. Back on the record.

Before I turn this over to Mr. Green, let me ask you some questions with respect to the Space Station which I think are important.

Last year I closed the discussion on the Space Station with these remarks, and let me quote: "And so, if you find out that your core Space Station is going to cost $10 billion instead of $8 billion, then don't come back to us and tell us that you want to stay within the $8 billion by knocking out a platform or knocking out a laboratory."

"Or, if you find that as this Station enters its development period, and like virtually every other NASA project, it encounters an overrun, then we don't want you to come back to us and say that you want to reprogram that money so that the manned element of the Station goes forward, and the laboratories and payload servicing and platforms are stretched out."

"And finally, we don't want to find ourselves in a situation where our Space Station turns into a housekeeping service for the Europeans and Japanese regardless of whether or not their modules are supposed to be shared with us. Those are the things that we are worried about."

I went on and on.

The answer was, "Mr. Beggs, I think I agree with that. Do you agree, Phil?"

And Mr. Culbertson said, "I don't find any problem with that."

COST OF SPACE STATION

Well, in the meantime, as your early Phase B work began to surface, it became clear that your $8 billion Space Station, which was to include two habitats, a materials processing laboratory, a life sciences laboratory, and two unmanned platforms, was going to cost $12 to $13 billion instead of the $8 billion you had pegged it at at that time. Apparently, that prompted you to cut out one of the U.S. laboratories, the life sciences laboratory, and to give that function to the Europeans.

Frankly, we don't have any problem with that, but from everything we are hearing, the Europeans are not really interested in building a life science module. They want to build a materials processing facility, as do the Japanese, and as do we, because everybody believes that is where the pay-off is going to be.

That is where our concern comes in, because we want to be sure that since we are putting 80 percent of the money into this Station, that we get the 80 percent advantage. I should say that is the primary and early advantage of being able to manufacture the equipment, and assemble the experiments and get into the spin-off benefits of any materials processing work.

So, the fundamental concern of the Subcommittee is that we be absolutely certain that the Station is funded in such a way, and that it is assembled in such a way, that the U.S. laboratory is fully capa~~ble of being used~~ as a man-tended proposition, if that becomes necessary, owing to budget problems.

We have no problem in proceeding on the path toward a permanently manned Station. Clearly, a permanently manned Station provides more manhours in orbit and therefore, should be more useful.

But the point is, useful to whom? We want to be sure that that usefulness is reflected in 80 percent of the benefits coming to us since we are putting up 80 percent of the money.

I think over the past 12 months, NASA has come our way. That is reflected in the current baseline assembly sequence which has a so-called man-tended capability by putting the lab up on the sixth flight.

Dr. Fletcher, we have been saying for more than two years that the budget crunch was going to pinch this program. That has begun to happen, and it will continue to happen unless NASA is given an extraordinary increase in its budget. I think our predictions on the budget problem have been fairly accurate, and so we are going to want to perhaps finely tune your proposal, because we are going to want to be sure that we don't trade our birthright in exchange for European, Japanese and Canadian contributions.

I hope you understand how we feel about this. I would also hope that this agency will be a little flexible, and not simply try to sometimes "sweet talk" us with a lot of nice words.

That is a long statement, and I would be interested in your response or anybody else's response.

You can understand our concern about the laboratories on the Station. I am sure you caught that, and you caught it last year.

Dr. FLETCHER. Yes, I am a new kid on the block, Mr. Chairman, but on the other hand, I agree with what I think are two elements of what you have said.

One is that if you think the Space Station is going to be costing more than whatever we guessed now, $8 billion, we ought to come and tell you that, and not try to cut things out of it and so forth, just build the Space Station that we advertised to you.

U.S BENEFITS OF SPACE STATION

Mr. BOLAND. Exactly.

Dr. FLETCHER. I agree with that statement. We shouldn't mess around with the original plan.

If I understood you correctly, the other point you emphasized is that if we put up 80 percent of the money, we want to make sure we get at least 80 percent of the benefits.

By the way, I am a nut on that one, and so I am going to insist on that.

We did some careless things back in the days just before I arrived on the scene in 1971 by getting the Japanese and others involved in competing with us.

I had the unpleasant duty of pulling back on some of these things, because of commercial technology transfers.

This is not military technology transfer, but commercial. We were pretty careful in the development of the shuttle to separate out a piece which we called the Spacelab and pretty careful not to allow any technology transfer although I imagine we transferred some management technology.

Bad as the media may make us out, we are still regarded by the rest of the world as pretty good managers of space programs.

Except for the management expertise, I don't believe we transferred a heck of a lot of technology to the Europeans.

They have grown and matured, so we can learn from them, to some extent, as well as they can learn from us.

But I think it is absolutely important that we get at least 80 percent. The reason I say "at least 80 percent" is because we will all get more than 100 percent if this thing is done right.

We will get not only the original purposes for which the Space Station was designed, but all the technological spin-offs, high-tech things that, as you may remember, we used to talk about in the early days, and I imagine still do.

So, we are all going to get more than 100 percent out of it, but our fair share has to be obtained.

Now, this is a matter of give and take. We can't just stonewall the Europeans and say, "We are not going to give you anything."

We have got to give them as much as they give us, and we keep our fair share, as you point out, with 80 percent.

I know you made a lot of other remarks along the way, but those are the ones I remember from what you said, and we are going to follow that procedure.

SPACE STATION MODULES

Mr. BOLAND. Do you have something to add, John?

Mr. Hodge. Just a point of reference with regard to the total number of modules.

We made a significant change in the design of the modules during the up-date process since we talked to you last year.

Originally, in the referenced configuration, we had the adapters that joined the modules together inside the module and that took up about close to a third of the total volume.

Now we realized that that was really a wasteful use of pressurized volume, so what we did was increase the length of the module to the maximum we could put in the shuttle.

We did that with some neat idea of how to get it out of the shuttle without hitting anything.

We were able to increase the length of the module by several feet. In addition to that, what we did was take out the adapters between the modules and put them outside so we have nodes and tunnels to join the modules together. That resulted in a much more efficient module pattern number one, and as a result within two modules we had almost the same volume as we had in the four modules before.

The European module is a little smaller, the Japanese is considerably smaller, so with regard to the total volume we actually have quite a bit more volume now that we have got the Europeans and the Japanese in there than we were talking about before.

With regard to the distribution of functions, as we began to look at the whole program it became obvious that we would be very wasteful if we just duplicated functions within modules. So we set up a process that we call functional allocation where there would be a primary function in each of the modules.

Now of course as you said everybody wants to do the same thing, so we have had some significant discussions about how that would finally end up. We have in our negotiations continuously stated that the primary function of the U.S. module would be materials processing. We have said that the primary function of the ESA module would be general science, and we have said the primary function of the Japanese module would be technology development.

Nevertheless, we have not precluded them from putting some of their other experiments in those modules. Now the fact is that when we start to operate the Station the majority of the time that we are flying, the majority of the crew people will be U.S. We will have crew people on there more or less proportional to our investment, which means that only 20 percent of the crews at any time will be international.

We have also in our negotiations absolutely insisted on equal access to all equipment, which means that we will be using everybody else's equipment most of the time and this principle of utilization proportionate to investment has been absolute to our negotiations, and we have never had any negation of that.

I believe that as we begin to build the Space Station, our international partners will realize that it is appropriate to put their equipment, for the things they want to do say in materials processing, in the U.S. lab because it is in the most preferred position, and has the lowest gravity.

I think we will all begin to do that. We have not yet got away from that sort of national enclave attitude and it is going to take a little while before people begin to realize that it makes sense to do it the way that we proposed.

As you go into the arguments, they are going to demand a pound of flesh for their pound of investment.

ESA AGREEMENTS

Mr. **Boland**. Did I hear you say this morning that you have had some agreement with ESA?

Mr. **Hodge**. It is getting close.

Mr. **Boland**. But there are problems, I take it, from what you are just saying.

Mr. **Hodge**. The problems are really related to whether or not the proposal of ESA to build a free-flying lab will be included as a part of their investment in the initial program or not. And we have taken a position that they will not, simply because we have as yet to find any uses for that facility and number two, it is essentially a user facility and not a facility which has equal access to everybody.

It is for those reasons that we have said that that should not be considered as a part of the investment.

SPACE STATION LABORATORIES/HABITAT

Mr. **Boland**. Let me say the thinking behind that long statement that I read is really the thinking behind this Subcommittee. We have stated that before. We stated it last year and there was general agreement on it. It is also, I think, generally supported by the Science and Technology Committee.

Phil, do you want to add something to that?

Mr. **Culbertson**. The only thing—yes, there are a couple things that I would add.

Whereas we were talking a year ago about as you said a two laboratory/two habitat Space Station, we now fundamentally have a one lab/three hab Station. One of the difficulties we faced was trying to achieve a reasonable balance between crew, power and volume which seems to us to be the basic parameters—the major parameters with which we were dealing.

After we had increased the size of the U.S. laboratory, had we added a second U.S. laboratory and ended up with four laboratories, it really didn't seem to be a consistent balance with a crew of 6 to 8 which is where we continue to stand, and with the 75 kilowatts of power that we have been planning.

It seems to me that we have achieved a much more effective balance of those resources and a satisfactory balance with the requirements of the user certainly in the early years of this.

I am sure that we will between now and then learn much more about how we will use the Space Station, but once we are using it we will continue to learn more.

I felt that, yes, I remember the discussion that you quoted very well. As we kept the Hill informed of the process that we are going through, it seems to me that we were still remaining consistent with the general concern of the Committee, although by increasing the size of the laboratory and that sort of thing, we certainly were not keeping numerical consistencies with what you asked for and what we agreed to do.

But you must realize also that the purpose of the program definition is to try to understand the kinds of issues that John was describing when we first concluded that the larger laboratory volume—the larger size module was much more important because it would allow new laboratory equipment to be installed later on as we came across the need.

With respect to the sequence in buildup, and the plan to have it useful as a man-tended configuration, I believe we came to a reasonable accommodation. You asked me, if I recall, you asked me if I was eager to do that study and I said no, we did it and I believe that concept also evolved properly between your staff and NASA and our contractors.

I believe we accommodated that to our generally mutual satisfaction. I hope that is true. You still have the report to read, I understand.

Mr. Boland. Thank you.

Mr. Green.

FUNCTIONAL ALLOCATIONS

Mr. Green. If I can briefly follow up on this discussion and turn to the shuttle issues.

I guess some impression from the course of the negotiations is that one might not have a lot of confidence in the functional allocation concept in the sense that once whoever it is gets going, they may be installing things on their part of it that start to get very near materials processing and life sciences. How do you deal with it?

Mr. Hodge. Well, although the whole world now is saying that materials processing is the coming thing, we have to make sure that we take into account all of the things that need to be done on the Space Station. Quite frankly, there is a tremendous growing interest in the life sciences function. Burt and I have been working on the requirements for the Space Station and I personally believe that we are going to see tremendous interest in two aspects other than the materials processing. They are going to be the life sciences side of it and particularly the technology development. We are starting to work a very close relationship with Dr. Colladay's organization and I personally see the ability to use what I have termed the Langley Research Center in Space, is going to emerge as one of the most interesting uses that comes out of the Space Station in the future.

There is one other point I wanted to make, and that is that in order to make sure that as people realize that this functional allocation makes sense. we have insisted on a common size of all racks. This means that any rack in any module will go in any other module. That is a baseline that everybody has agreed to and whether or not we can come to the absolute agreement on what things are going to go in what module right now, 3 or 4 years after we are up and everybody realizes we have got to make this as efficient as possible, we can move anything from one module to another.

That has been a very important part of the design concept.

COST PER FLIGHT

Mr. **Green**. Let me return to the shuttle. We are going to have to make some decisions and those may vary on what the Administration ultimately chooses to request. Certainly one issue is the question of pricing, and the cost of the various ways of lifting things into space.

Let me start with a memo dated February 16, 1983 from the then Deputy Administrator, Dr. Mark, to the Assistant Administrator for Legislative Affairs. I will just quote part of it.

"During the 1970s NASA inflated the mission model far beyond any realistic limits in order to reduce the apparent cost per flight of the shuttle. In fact, the mission model used to arrive at the agreement with DoD was developed by NASA in the mid-1970s and was designed solely to push the cost of shuttle flights below that of the cost of the ELVs."

Then, going further, skipping over, "we must admit that the shuttle is not cheaper to operate than currently available ELVs at the present time. It may eventually be less expensive than ELVs, but this will happen only when we really understand all the operational costs of the shuttle.

"The real reason for developing the shuttle is to acquire new capabilities in ELVs that will provide capabilities for us."

Obviously, there are such capabilities, I don't think anyone on this Subcommittee challenges that. But the question of whether we will launch things in the future with a replacement orbiter, or with ELVs is very much before us.

I would suppose that events since February 16, 1983 have not shifted the costs favorably towards the shuttle. You have had the problem of the main engine and the difficulties you have getting it to 109 percent, and you will be flying fewer flights in the year than anticipated, so the same overhead will have to be spread among fewer flights.

ELV'S FOR NASA AND DOD

There are lots of things that tilted the balance. Presumably, you will have to beef up safety. All that argues to make the shuttle more expensive. Why then isn't NASA considering an ELV capacity for NASA as well as for the Defense Department?

Dr. **Fletcher**. Mr. Green, that is an awfully good question. Quite frankly, I don't believe Dr. Mark made an analysis that had to have been made then, and I think what we will have to do now is to make an estimate of how much the overall cost of launching things into space will be as a function of how many orbiters and expendables we have, DOD, and maybe commercial ELVs, for all I know.

That analysis really needs to be done again. I don't believe it has been done well since the 1971 period that we were referring to earlier. That really needs to be revisited again.

We have made some starts on that at NASA, and we are beginning to develop mission models, other people would call it manifests, for the shuttle. But without looking at all the likely missions to be flown over the next 10 to 15 years, it is hard to make an estimate of what is the most cost-effective way of launching.

Having said that, it is pretty clear in the near future we are not going to have enough orbiters to launch all the missions that are required. So we have to go to ELVs in the near future. The near future may last longer than some of us think.

Mr. GREEN. I gather you are talking about DOD?

Dr. FLETCHER. And even the commercial users. They are going to have to find a way of launching their vehicles, because we don't have enough room for the next several years for all the commercial launches, either.

Mr. GREEN. So, you are conceiving of some third launch capacity in this country, a non-DOD, non-NASA commercial launch capacity?

Dr. FLETCHER. I expect so, in the next three or four years. That analysis, however, has not been done. I am hoping that in the next several weeks, hopefully not longer, we will have a good mission model, and a good analysis of what the optimum is.

Remember even though the optimum may turn out to be so many orbiters and so many commercial ELVs and so many DOD, DOD has the additional constraint of being able to launch on emergency basis of their own, which may raise the overall cost of the fleet.

In the immediate future, yes, there are going to be more ELVs, Where they will come from is, I think, the question, and we have not resolved that yet.

ALTERNATIVE LAUNCH VEHICLES

Mr. GREEN. I gather from some discussions, both directly and through staff with Air Force people, that there are some significant savings to be achieved from the reworking of the Titans.

Have you looked at that?

Dr. FLETCHER. Admiral Truly will have to answer more correctly, but I can say that we have looked only briefly at that, but there is more to it than just modifying the Titans.

They are also thinking of building up smaller expendable lines, the Centaur and possibly even the Deltas. That whole thing has not been mixed in together with our own needs. That needs to be done, and I hope will be done in the near future.

Mr. GREEN. It does seem to us that that enters into the calculation of whether to order a replacement orbiter.

Dr. FLETCHER. It does to some extent. On the other hand, you do need a replacement orbiter, at least four flying in order to have a reasonable fleet, for no matter what we do in the future, particularly with the Space Station.

Mr. GREEN. I guess what I really need then, our problem is, of course, that we are under orders from the Gramm-Rudman law to have a bill passed by the House by the end of June, and our penalty is we are not allowed a July 4 recess if we don't.

Dr. FLETCHER. I think the justification for the fourth orbiter, I hope I made this clear, is not only based on cost-effectiveness, it is basically what you need for a space transportation system for NASA alone, especially during the era of the Space Station.

On the other hand, how many ELVs we buy, and so forth, will depend on that analysis.

Mr. **Green**. I think we do need that laid out for us year by year, what are the manifests that will only fly the orbiter as opposed to potential ELV flights.

Dr. **Fletcher**. That needs to be done. Having said that, Admiral Truly can give you—and Dr. Graham has been working that problem—a better picture of where that mission assistance stands.

Mr. **Green**. I think we are five minutes from the vote, so—

Mr. **Boland**. Why don't we get that answer for the record?

[The information follows:]

ELV COST COMPARISON—COST PER LAUNCH, FOUR PER YEAR RATE

[In fiscal year 1986 dollars]

	Cost	Performance lbs. to GEO orbit
Delta	$47 million	1,300
Atlas Centaur	80 million	2,400
Titan 34-D/IUS	143 million	4,100
Titan 34D-7/Centaur	162 million	10,200

*** SHUTTLE FLIGHT ASSIGNMENTS FOR PAYLOADS ***

NOVEMBER 1985 BASELINE

MSSN	DATE ORBTR	INCL ALT	CRW DUR	PAYLOAD	CARRIER	
61-B 31	85 11 26 ATLANTIS	28.5 190	7 7	EASE/ACCESS MORELOS-B SATCOM KU-2 AUSSAT- 2	MPESS PAM-D PAM-D2 PAM-D	
61-C 32	85 12 18 COLUMBIA	28.5 175	7 5	MSL- 2 GAS BRIDGE SATCOM KU-1	MPESS PAM-D2	
51-L 33	86 1 22 CHALLENGER	28.5 153	7 6	SPARTAN-HALLEY TDRS-B	MPESS IUS/2	
61-E 34	86 3 6 COLUMBIA	28.5 190	7 9	ASTRO-1 - Shuttle	IC+2P	

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*** SHUTTLE FLIGHT ASSIGNMENTS FOR PAYLOADS ***
NOVEMBER 1985 BASELINE

MSSN	DATE ORBTR	INCL ALT	CRW DUR	PAYLOAD	CARRIER	
62-A 1	86 3 20 DISCOVERY	0.0 0	0 0	DOD(V)		
61-F 35	86 5 15 CHALLENGER	28.5 110	4 4	ULYSSES – Titan 34D-7 and Kick stage *	'CENTAUR	
61-G 36	86 5 20 ATLANTIS	28.5 110	4 4	GALILEO-Titan 34D-7 and Kick stage *	'CENTAUR	
61-H 37	86 6 24 COLUMBIA	28.5 190	7 7	WESTAR VI-S Delta 3920 PALAPA B-3 Delta 3920 SKYNET-4A Delta 3920A	PAM-D 'PAM-D PAM-D2	
61-M 38	86 7 22 CHALLENGER	28.5 154	6 5	EOS-1 - Shuttle TDRS-D Titan Centaur or IUS	 IUS/2	
61-J 39	86 8 18 ATLANTIS	28.5 320	5 5	HUBBLE SP TELS – Shuttle		
61-N 40	86 9 4 COLUMBIA	0.0 0	0 0	DOD		

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* Requires development

*** SHUTTLE FLIGHT ASSIGNMENTS FOR PAYLOADS ***
NOVEMBER 1985 BASELINE

MSSN	DATE ORBTR	INCL ALT	CRW DUR	PAYLOAD	CARRIER	
61-I 41	86 9 27 CHALLENGER	28.5 230	7 5	LDEF-1 RETR Shuttle INSAT 1-C Delta 3920	 PAM-D	
62-B 2	86 9 29 DISCOVERY	0.0 0	0 0	DOD(V)		
61-K 42	86 10 27 ATLANTIS	57.0 135	7 7	EOM-1/2 Shuttle	SM+1P+MP	
61-L 43	86 11 6 COLUMBIA	28.5 160	7 7	MSL- 3 Shuttle GSTAR-III Delta 3920A SYNCOM IV-5 Shuttle	MPESS PAM-D2	
71-B 44	86 12 6 CHALLENGER	0.0 0	0 0	DOD		
71-A 45	87 1 12 ATLANTIS	28.5 160	7 7	ASTRO-2 Shuttle DOD PAM- 1 ELV compatible	IG+2P PAM-D2	
71-C 46	87 1 27 COLUMBIA	28.5 190	7 7	SHEAL- 1 Shuttle ASC- 2 Delta 3920X SKYNET-4B Delta 3920A SPARTAN-2 Shuttle	SPOC PAM-D PAM-D2 MPESS	

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*** SHUTTLE FLIGHT ASSIGNMENTS FOR PAYLOADS ***

NOVEMBER 1985 BASELINE

MSSN	DATE ORBTR	INCL ALT	CRW DUR	PAYLOAD	CARRIER
71-D 47	87 2 16 CHALLENGER	28.5 160	6 7	EOS-2 Shuttle TDRS-C Titan Centaur or IUS	 IUS/2
71-E 48	87 3 16 ATLANTIS	28.5 160	7 7	SLS- 1 Shuttle	LM
72-A 3	87 3 18 DISCOVERY	88.0 163	5 5	SRL- 2 Shuttle PL OPPTY	IP+MPESS
71-F 49	87 3 24 COLUMBIA	28.5 160	5 7	MSL- 5 Shuttle DOD PAM- 2 } ELV DOD PAM- 3 } compat.	MPESS PAM-D2 PAM-D2
71-G 50	87 4 14 CHALLENGER	28.5 160	6 7	MSL- 4(MEA) } SSBUV- 1 } Shuttle EOIM-III } HS 376-R Delta 3920 DOD PAM- 4 ELV Compat.	MPESS MPESS PAM-D PAM-D2
71-H 51	87 5 18 ATLANTIS	0.0 0	0 0	DOD	

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Mr. **Boland**. Mrs. Boggs has one question that she would like to ask, then we are going to adjourn. I know you are happy about that.

TANK PRODUCTION IMPACT

Mrs. **Boggs**. I have a question about the shuttle, which has some parochial applications for my district. Can you tell me how the present crisis will impact upon the production of the number of tanks to be produced this year?

Dr. **Fletcher**. That is a good question, and I am afraid I am not on top of it. Whether Dick Truly is, I will try Dick anyway.

Mr. **Green**. While they are checking, can I ask for the record, to supply, if we could get it by next week, a sort of matrix showing year by year what each of the programs you have?

My question is, it is plain you will not get the 1 percent per annum real growth that OMB promised when you started the Station. I think we have to really see how you would function in this more constrained fiscal environment.

[The information follows:]

*** SHUTTLE FLIGHT ASSIGNMENTS FOR PAYLOADS ***
NOVEMBER 1985 BASELINE

MSSN	DATE ORBTR	INCL ALT	CRW DUR	PAYLOAD	CARRIER
71-I 52	87 5 27 COLUMBIA	28.5 160	7 7	IML- 1 Shuttle	LM
71-J 53	87 6 9 CHALLENGER	57.0 245	5 4	LDEF-2 (HNC) Shuttle	
71-K 54	87 7 15 ATLANTIS	28.5 160	5 7	MSL- 7 Shuttle INTELSAT VI- 1 Titan DOD PAM- 5 ELV Compat.	MPESS Centaur PAM-D2
71-L 55	87 8 4 COLUMBIA	28.5 160	5 7	MSL- 6(MEA) SSBUV- 2 SPARTAN-3 } Shuttle DOD PAM- 6 DOD PAM- 7 } ELV Compatable	MPESS MPESS PAM-D2 PAM-D2
71-M 56	87 8 18 CHALLENGER	28.5 193	7 7	ASTRO-3-Shuttle CRRES-Atlas-Centaur *	IG+2P
71-N 57	87 9 17 ATLANTIS	0.0 0	0 0	DOD	

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* Requires uprated version - not developed

*** SHUTTLE FLIGHT ASSIGNMENTS FOR PAYLOADS ***
NOVEMBER 1985 BASELINE

MSSN	DATE ORBTR	INCL ALT	CRW DUR	PAYLOAD	CARRIER
71-O 58	87 9 28 COLUMBIA	57.0 256	5 7	SUNLAB- 1 Shuttle ROSAT Altas Centaur	IG+IP
81-A 59	87 10 21 CHALLENGER	0.0 0	0 0	DOD	
81-B 60	87 11 9 ATLANTIS	28.5 160	5 7	MSL- 8 } Shuttle SPARTAN 205 STC DBS-A Delta 3920A RCA-4001 Atlas Centaur	MPESS MPESS PAM-D2 SCOTS
81-C 61	87 11 16 COLUMBIA	28.5 160	6 7	SSBUV- 3 Shuttle DOD PAM- 8 ELV SBS- 6 Atlas Centaur PL OPPTY	 PAM-D2
81-D 62	87 12 22 CHALLENGER	28.5 160	6 7	GALAXY KU-1 Atlas Centaur DOD PAM- 9 } ELV DOD PAM-10	 PAM-D2 PAM-D2
81-E 63	88 1 25 ATLANTIS	0.0 0	0 0	DOD	

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*** SHUTTLE FLIGHT ASSIGNMENTS FOR PAYLOADS ***
NOVEMBER 1985 BASELINE

MSSN	DATE ORBTR	INCL ALT	CRW DUR	PAYLOAD	CARRIER	
81-F 64	88 2 2 COLUMBIA	28.5 160	6 7	EOM- 3 Shuttle DOD PAM-11 ELV STC DBS-B Delta 3920A	IG+IP PAM-D2 PAM-D2	
81-G 65	88 2 23 CHALLENGER	57.0 200	7 7	SPACELAB J Shuttle	LM	
81-H 66	88 3 24 COLUMBIA	28.5 160	5 7	MSL- 9 Shuttle SPARTAN 206 Shuttle EURECA Shuttle DOD PAM-12 ELV	MPESS MPESS PAM-D2	
82-A 4	88 4 1 DISCOVERY	0.0 0	0 0	DOD(V)		
81-I 67	88 4 6 ATLANTIS	28.5 160	4 2	VRM Titan 34D-7	CENTAUR	
81-J 68	88 5 4 CHALLENGER	0.0 0	0 0	DOD		
81-K 69	88 6 8 ATLANTIS	28.5 160	5 7	SSBUV- 4 Shuttle DOD PAM-13 ELV GRO Titan Centaur	 PAM-D2 	

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*** SHUTTLE FLIGHT ASSIGNMENTS FOR PAYLOADS ***
NOVEMBER 1985 BASELINE

MSSN	DATE ORBTR	INCL ALT	CRW DUR	PAYLOAD	CARRIER
81-L	88 6 14	28.5	5	SPARTAN 211 } Shuttle	MPESS
70	COLUMBIA	160	7	MSL-10	MPESS
				DOD PAM-14 -ELV	PAM-D2
				PL OPPTY	
82-B	88 7 15	99.0	5	COBE Titan 34D-7	
5	DISCOVERY	160	7	PL OPPTY	
81-M	88 7 20	28.5	7	SLS- 2 Shuttle	LM
71	CHALLENGER	160	7		
81-N	88 8 10	0.0	0	DOD	
72	ATLANTIS	0	0		

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→17/87BUDGET/87RUNOUT
5/20/'

APPROXIMATE FY 1987 BUDGET RUNOUT ADJUSTED FOR IMPACT OF ACCIDENT

	1986	1987	1988	1989	1990	1991
Revised NASA Budget Runout						
Space Station	195	410	1000	1800	1950	2170
Space Science & Applications	1477	1460	1500	1550	1600	1650
Aero & Space R&T	497	556	555	560	580	600
TAV	--	45	56	75	140	100
Commercial Programs	27	45	54	60	60	60
STS Capability Development	404	536	540	460	490	370
STS Production	888	716	595	550	600	560
STS Operations	1640	1396	1650	1370	1500	1640
Tracking & Data Acquisition	675	890	930	970	1100	1060
R&PM	1341	1425	1460	1490	1530	1580
CofF	133	181	150	150	150	150
Anomaly Resolution	56	34				
TOTAL	7333	7694	8490	9035	9700	9940
Anomaly Resolution	200	250	50			
TOTAL - Excluding Orbiter Hardware Replacement	7533	7944	8540	9035	9700	9940

Dr. **Fletcher**. We will do our best to do that, but of course, we are not that far along in the study, so it will only be a first cut.

Admiral **Truly**. In answer to your question Mrs. Boggs, I wanted to check it. We have slowed the production rate of external tanks and there have been some layoffs down there as a result of that. However, we have not stopped production, but we will continue to assess this. As of the time that we made the decision to cut back on production, it was obviously something that needed to be done, but at that time, we did not have a new launch date nor projected flight rate.

So, we are going to have to continue to look at the tank production rate in the future to assure that the inventory that we have, and the production rate meets what we realistically think we will be achieving.

Mrs. **Boggs**. Mr. Chairman, the tanks always come in under budget and ahead of schedule, so we have several on hand. But will there be any changes made in the design of the external tank?

Admiral **Truly**. Not that I am aware of.

Mrs. **Boggs**. Thank you very much.

Thank you, Mr. Chairman.

Mr. **Boland**. Thank you very much.

The Committee will stand in adjournment. We would be delighted to have you join us next week for another interesting session.

Thank you.

TUESDAY, MAY 20, 1986.

OPENING REMARKS

Mr. BOLAND. The Committee will come to order.

Off the record.

[Discussion off the record.]

Mr. BOLAND. We are delighted again to have with us the officials from NASA and the Administrator, Dr. Fletcher.

As I indicated the other day, this Committee has a very significant responsibility to the Congress and to the House to delve into the very many programs that NASA has. Over the years, I think as has been testified to in the past and agreed to by a great number of Members, this Committee at times delves rather deeply into some of the questions with which we are concerned, and which the Congress is concerned with.

This is the Committee that has to carry the ball when we get to the floor. The Science and Technology Committee is an essential part of the whole legislative process, of course, and the cooperation we have with that Committee is probably as good as any of the 13 Subcommittees that deal with the substantive Committees of the House.

But in the final analysis, it is the money that really counts for any agency that is going to do its duty and the responsibility imposed upon them. We are going to have some very deep and probing questions today on NASA, and particularly perhaps this afternoon on the Space Station with which we are very, very concerned.

It is our desire to get some answers out, or specific answers on some of the questions that will be asked with reference to the Space Station, not a lot of glowing words, We want some specific answers on some of the questions that are going to be asked with reference to Space Station, and we want to find out just exactly what it is going to cost, what the contributions are going to be on our part, what the contributions will be on the part of our friends who will be joining us in that particular venture if we ever get into it, and also to get a pretty clear picture of where we are going, what we are going to do, and what our responsibility is.

I know this presents a problem for some; it presents a problem for us, of course, but we are going to pay the bulk of the freight there. If this is going to be an $8 billion program, one that started out with a baseline of $13 billion and is now squeezed into $8 billion, we want to know precisely what we have lost or what has been lost as a result of the squeeze.

So you can be thinking of that and those are the questions we will be getting into.

We will also be getting into the question of the upper stage and whether or not the Centaur is the vehicle that ought to be used.

We have the Surveys and Investigations staff out there, who will be reporting back to this Committee within a relatively short period of time. That has been a rather deep investigation by the staff of this Committee. As I have said many times, I think the Appropriations Committee has one of the best arms in investigations on this Hill, the Surveys and Investigations staff of this Committee, who are totally objective. We are going to listen to them when they come back to us. We will have some questions whether or not the Centaur is a vehicle that ought to be used at that stage, and whether or not without it we can launch some of the satellites that NASA intends to launch over the next few years.

We also will be getting rather deeply into whether or not we need a fourth orbiter. When we look at the manifest and look at the flights scheduled by NASA over the next few years, the questions are being raised in many areas as to whether or not we really need a fourth orbiter, and whether or not we will proceed along the line of a combination of what we have now—the three that we have, Columbia, Atlantis and Discovery—and whether or not we can do the job that that manifest calls for over the next few years in conjunction with some of the big ELVs that are going to be used by the Department of Defense to launch some of its satellites.

You probably saw the article in the *New York Times* today on the newest Titan 34-D7 that has seven segments and can launch just about everything. I guess there is some question whether it can launch all of the satellites, and whether it has the thrust to do it.

But we, this agency and this Committee, are in a position of making some judgments that will have to be considered seriously by those who administer this program. As I have indicated, we have no intention, on the part of this Committee, of managing the agency, but there is a very definite responsibility on the part of this Committee to be sure that we get what we buy and to be sure whether or not those are the kinds of programs we ought to be proceeding with.

I don't think anybody could really quarrel with that particular position. No one ever has before and it is our intention to work with NASA to be sure that we can be helpful and, with this NASA administration, to be doing what it has to be doing with reference to the authorization and spending of the funds.

DISPOSAL OF DOCUMENTS

Before we go on, let me ask one question about the document problem at Marshall. I was not around when this story broke last week, but my understanding is that the FBI has cleared it; at least the spokesman for the Presidential Commission has indicated there is no problem there, and we are glad to hear that. My understanding is that copies of the documents were not destroyed intentionally, as I understand it, but rather routinely. Copies of those documents are still available to the President's Commission, and I understand the President's Commission is satisfied.

With that explanation, I don't know—is Bill Colvin here, of the IG? Has he made his report yet? Go ahead, Bill.

Dr. **Graham**. Yes, Mr. Chairman, the Presidential Commission has indicated to us that their investigation showed them that no documents necessary for their investigation were in fact unavailable. Copies of pertinent documents all seem to be in the records at Marshall. The Inspector General investigation of the situation is continuing to determine if proper procedures were followed after the impoundment and in related matters.

We are continuing to look at it. But I believe the Commission has found that its work has not been impeded by anything that is missing from Marshall.

Mr. **Boland**. It has been documented that these documents were not intentionally destroyed but were routinely disposed of?

Dr. **Graham**. Those are certainly the indications we have seen to date, although our IG report is not complete on it.

Mr. **Boland**. When do you expect the Inspector General's report to be available?

Dr. **Graham**. I would have to check with Bill Colvin to give you a hard date. I would expect within the month. He is very busy with a number of things that might slow it down slightly.

Dr. **Fletcher**. I want to emphasize something that Dr. Graham said, that our IG is only looking to see if our procedures have been violated, not to see whether any documents are destroyed. We accept the Commission's report that no documents were destroyed that didn't have duplicates.

Mr. **Boland**. As I understand it, am I correct in thinking that disposal of documents has been a routine procedure? There must be an awful lot of them.

I understand there is a distribution to about 33 particular individuals and that there are a considerable number of them which are filed by, unsigned as I understand it, and presented to these individuals and that has been occurring over long periods of time and in order to get rid of some of that paperwork and filing, why, if you have copies, I understand this has been a routine procedure, is that correct?

Dr. **Fletcher**. That is correct, Mr. Chairman. In fact it probably happens at other centers as well. We don't like to be stuck with too much paperwork. It doesn't ultimately result in something that goes into the file anyway. We may even do it at Headquarters for all I know.

Mr. **Lewis**. Mr. Chairman.

Mr. **Boland**. Yes.

Mr. **Lewis**. I am sorry to interrupt at this point, but it occurs to me that Members of the Committee probably reacted in similar fashion to my own reaction when this news report came forth regarding this shredding. To say the least my reactions were similar to what I believe the Chairman's were.

Having said that, it appears that the reporting itself was full of misinformation rather than helpful information. At a time when the agency is faced with some considerable public relations crisis, if you will, that sort of reporting tends to undermine rather than help the press.

I don't know how it occurred but I didn't want that to go unsaid.

FUNDING PROFILE THROUGH FY 1994

Mr. **Boland**. True. Thank you very much.

For the benefit of all the Members on the Subcommittee as you know, we will be dealing not specifically with all of the budget justifications because there has been a change in the funding needs, a complete reshuffling of the budget, which of course was necessitated by the loss of the Challenger.

So let's begin by taking a look at the big picture for a minute. The staff received what is a very rough analysis of NASA's funding profile out through fiscal year 1994 with these assumptions: one, a new orbiter; two, $500 million to fix the solid rocket boosters; three, to accommodate the funding of a space station; and four, to accommodate the funding of a transatmospheric vehicle.

When that is all added up, the figures come to these amounts: for fiscal year 1987, $8,676,000,000; 1988, $9,411,000,000; fiscal year 1989, $9,377,000,000; and fiscal year 1990, $9,657,000,000.

Given the implications of Gramm-Rudman, and given the overall difficulties of the budget situation, I think it is kind of difficult to realize how are you going to have a budget request of $9,400,000,000 in fiscal year 1988. Of course, these figures do not include any particular new starts.

That is correct, is it not, Jim?

Mr. NEWMAN. Yes.

FOURTH ORBITER FUNDING

Mr. BOLAND. Rather, Tommy. By the way, these figures do not include a new start for the Advanced X-ray Astrophysics Facility. Had that been in a plan for 1988 as a new start?

Mr. NEWMAN. Well, the 1988 budget is yet to be determined.

Mr. BOLAND. But you are thinking—

Mr. NEWMAN. It would be a candidate for a start in 1988.

Mr. BOLAND. And would that have been a candidate, or would that amount have been included for that particular facility within the $9,400,000,000 for 1988?

Mr. NEWMAN. The $9.4 billion does not include provision for new initiatives in the space science area. We were responding to a question when we developed those figures including replacement of the orbiter and completion of the anomaly resolution, and completion of the programs in the 1987 budget.

EFFECTS OF DEFICIT REDUCTION ACT

Mr. BOLAND. I know that NASA believes that the Administration will provide funding for a fourth orbiter over and above what you feel is the base NASA budget. But when you consider Gramm-Rudman, does the Administration want NASA to find offsets for that someplace in the budget?

Dr. FLETCHER. Mr. Chairman, I ought to address that since I have been involved in many of the discussions with the White House. Of course they are worried about the Deficit Reduction Act and that is one of the reasons that we don't have a supplemental yet. They are trying to reconcile what is required by the Deficit Reduction Act in 1986 and 1987, and looking towards 1988 as well. As you pointed out, we just don't know how it is going to come out. There is pressure to try to pull something out of NASA to meet the Deficit Reduction Act requirements. That has not been resolved yet and it is still under discussion.

Mr. BOLAND. We have a problem, too, of course, with the amount to be allocated under the 302(b) allocation to this Subcommittee. As you know the House Budget Committee allocates to the Appropriations Committee a huge sum which is then allocated to the 13 various subcommittees of the Appropriations Committee. We have to make specific judgments on how we can fit that allocation into the many programs that this Committee considers, and specifically the big agencies, in which there is a considerable amount of discretionary funding.

The Veterans Administration, for instance, has a budget of about $25 billion but the vast majority of that, of course, is mandatory; it is an entitlement program and we don't really have much leeway. So, the only place we have leeway to make particular reductions which would be forced upon us, vis-a-vis the allocation given to this Committee, will be in some of the discretionary funding; this is one of the agencies that we will have to consider.

Dr. **Fletcher**. Mr. Chairman, if I could just add one more thing, being the new kid on the block here, during the six years that I was here NASA never asked for any supplemental, but we didn't have any accident like we just had either. So it is just a most unfortunate situation we find ourselves in. A supplemental is supposed to take care of emergencies. If there ever was an emergency in NASA, we just had one. And the problem is how do I reconcile that emergency with the Gramm-Rudman Deficit Reduction Act? That is what you have to deal with and we have to deal with, too. We have not resolved it yet.

Mr. **Green**. Mr. Chairman.

Mr. **Boland**. Sure.

BUDGET GROWTH

Mr. **Green**. I acknowledge the point you are making that the problems of either replacing the fourth orbiter or turning to expendable launch vehicles are issues that truly could not have been anticipated. But you have been good enough to provide me with a runout of your 1987 budget for the future years, and while it is adjusted for the impact of the accident, it does not pick up orbiter hardware replacement, the kind of thing that would be covered by the supplemental request.

Yet as I run the total numbers just for the first couple years, not only are you assuming the 1 percent increase above inflation that was the agreement with OMB in 1984, but you seem to be something close to 3 percent in 1987 over 1986, something close to 2 percent in 1988 over 1987. I understand that these figures are given to me at a 3 percent inflation rate, and in nominal dollars. You seem to be exceeding inflation not by 1 but close to 2 or 3 percent. I wonder if that whole possibility is real in this budget climate even if we had not had the Challenger tragedy.

Dr. **Fletcher**. Mr. Newman will have to answer that one.

Mr. **Newman**. Mr. Green, the 1 percent that was agreed upon at the time of the Space Station would have resulted in a budget of about $8.3 billion in 1987 and about $8.5 billion in fiscal year 1988. And up to about $9.9 billion by 1991.

Mr. **Green**. You are assuming in these figures that you can get back on that track despite the setbacks of the last two years?

Mr. **Newman**. The runouts of this budget as adjusted by the accident and not including the new orbiter are approximately in line with those figures. Now, the difference between those figures that

Mr. Boland just read and the figures on the sheet you have are essentially the cost of the orbiter hardware.

Mr. **Green**. I understand that, but what I am saying is you are projecting a runout of costs entirely apart from the replacement of the orbiter so that from the base from which we are now starting, and that is how everything is being measured here in Congress as we go through this deficit reduction exercise, you are assuming some fairly substantial increases above inflation whereas most accounts are being held by the Congress to a freeze in terms of nominal dollars with no allowance for inflation.

I wonder how realistic it is for you to plan on a program over the years in light of the targets that the Congress and the President have set for us.

Mr. **Newman**. The President's budget in January did carry the $9.9 billion in 1991 and figures that build-up to that.

The question we were answering here is the question which I understood was requested: What would be the cost of continuing the programs in the 1987 budget with the adjustments necessary because of the accident and providing for the other items you have discussed?

So we answered that question directly.

Mr. **Green**. And I appreciate it and I think it is very helpful to have these figures. The problem I am having, though, is that as I look at the figures they are saying to me that if the present budget climate continues, your program cannot be accomplished.

Dr. **Fletcher**. Mr. Green——

Mr. **Green**. And could not have been accomplished even before the Challenger accidents.

Dr. **Fletcher**. I am not sure I understand all the 1 percent and 3 percents, but it is necessary to have some increase in the budget in the outyears due to the Space Station, which is a high priority program, and still keep a balanced program within NASA. We couldn't go ahead with the Space Station and cut out science and aeronautics and all the other things.

Mr. **Green**. I quite agree with you.

Dr. **Fletcher**. How can we accommodate a Space Station without some increase in the outyears is, I guess, our question.

Mr. **Green**. I think that is the dilemma both you and we are facing.

Dr. **Fletcher**. Yes.

Mr. **Green**. Thank you, Mr. Chairman.

BUDGET PRIORITIES

Mr. **Boland**. These are questions which clearly indicate something has got to give somewhere in this budget.

Let me ask you—if it is a choice between fully funding the Space Station to meet the 1994 permanently manned date, if it is a question of that versus the orbiter, which has the highest priority? Don't tell me they both enjoy the same priority. I don't want to hear that answer because that isn't the kind of answer that satisfies who that we have to meet when we bring this bill to the Floor.

Dr. **Fletcher**. Mr. Chairman, those two are coupled. You really can't have one without the other. If you don't go ahead with——

Mr. **Boland**. Can't you really have one without the other?

Dr. **Fletcher**. Not really, for the following reason: Even though in principle you can take care of all your payloads with three orbiters, that is a pretty marginal situation, and I think I can say with some feeling that we should never have cut back from five to four. But, of course, that is past.

We all knew we might run into a problem like this someday, but never thought it would be this disastrous. But you do need a minimum size fleet, and four orbiters is I think an absolute minimum. If you went ahead with a three-orbiter fleet, just a small accident would cause all kinds of repercussions throughout NASA, including the Space Station.

On the other hand, if you don't go ahead with the Space Station, you first of all have not met a Presidential commitment, but you also are going to cost the country more, and you are going to find yourself farther and farther behind your long-range objectives in space, not the least of which is to try to keep some kind of pace with what foreign governments are doing in this arena. We are behind, and we are catching up in the Space Station arena.

Mr. **Boland**. I take it that you attach a high priority to both of the programs, then?

Dr. **Fletcher**. I would have to say that, Mr. Chairman.

Mr. **Boland**. You would not choose one over the other?

Dr. **Fletcher**. I don't see how I can, as Administrator of NASA, choose one over the other.

Mr. **Green**. Of course, that leaves us in the position that when we get a fixed sum, we may have to make some choices.

I wonder whether it isn't better, at least in the first instance, to have you make some recommendations to us.

Dr. **Fletcher**. I would rather squeeze everywhere else first before I chose between one or the other of those.

Mr. **Green**. But you will be getting back to the space science and aeronautics.

Dr. **Fletcher**. And you will be getting an unbalanced program. So, we are kind of caught in a dilemma. No matter where we squeeze, we will be in trouble.

Mr. **Boland**. Do any Members have questions in this area? Then we will get a little deeper.

Mr. **Lewis**. Mr. Chairman, I have, rather than a question, a reaction to the line of inquiry.

Obviously, the Challenger tragedy creates a totally different environment, and our choices are first, making the kind of choices the Chairman has suggested, the decisions being made by either NASA or the Congress, or, secondly, our being willing to bite the bullet and say to the public indeed this is an emergency and we think you have supported this program, so we are going to go the extra mile and literally push our other budgets around because of NASA's priority. I think the crunch will come then.

My own bias is already clear to the Members of the Subcommittee, but it is very apparent that we are at our best when we are faced with unusual challenges, and this is one of those times.

FY 1987 SHUTTLE ACCIDENT IMPACT

Mr. **Boland**. Well, I don't think anybody would disagree with that statement.

Let's get a look at the fiscal year 1987 for a moment. The table on—I am looking at a table—do all Members have this particular table? They don't.

You can't follow the numbers in the justification because of the accident which has impacted the spending in particular areas. NASA has now sent up new figures in this area.

The table that the Committee has indicates that when you add up all of the savings occurring because we are not flying the shuttles, that total is about $497 million.

Do you have this table?

Dr. **Fletcher**. Yes, sir.

Mr. **Boland**. Specifically, it lists the particular areas which the $497 million is saved. Then when you add up all the costs of not flying shuttles, it totals about $453 million. So, there are about $37 million available for fixing the solid rocket booster problem.

Is that about right, Tom?

Mr. **Newman**. Yes, sir. That is the table that we developed shortly after the accident; we think the figures are still approximately correct.

Mr. **Boland**. In addition to that, and in addition to funds for a new orbiter, you require about $500 million between 1986 and 1987 to fix the SRB, solid rocket booster; is that correct?

Mr. **Newman**. That is correct.

Mr. **Boland**. Is it also true that the assumptions on this table are based on our ability to appropriate the full $7,694,000,000 requested?

Mr. **Newman**. Yes.

Mr. **Boland**. And they do not take into account—or do they—the fact that we have to find somewhere between $90 million and $100 million for the Advanced Communications Technology Satellite?

Mr. **Newman**. They do not take that into account.

SPACE SCIENCE BUDGET RATIO TO NASA TOTAL

Mr. **Boland**. The point of these questions is that what is happening here is that NASA is trying to put, as somebody once said, 10 pounds of potatoes into a 5-pound bag—and that is rather difficult to do.

Let me ask you, in terms of the fiscal year 1987 budget, does your request meet the agreement between NASA and this Committee, and, for that matter, the whole Congress—since the Congress approved the report and action we took in this area with respect to this question—that the Space Science and Applications part of this budget will remain in the same ratio to the total NASA budget as the Space Station program proceeds?

Mr. **Newman**. The science and applications budget is about 24 percent of the total, and that is basically the ratio we have had.

Mr. **Boland**. That ratio will be maintained as the Station program proceeds; is that correct?

Dr. **Fletcher**. Mr. Chairman, you can't do it exactly; but approximately we will try to maintain that ratio. Things are always going to go up or down a little bit from that number, of course.

Mr. **Boland**. But substantially?

Dr. **Fletcher**. Not substantially different from that 24 percent.

ACCOMMODATING SHUTTLE PAYLOADS

Mr. **Boland**. All right. Let's turn to a little more conversation specifically about the shuttle—fixing the SRBs and buying a new orbiter, and the tradeoffs between a new orbiter and the ELVs.

Let's talk about the 1989, 1990, 1991 time frame. Before the accident, NASA's position was pretty clear. There was more than sufficient payload capacity on a four-orbiter fleet to handle all DOD, NASA, and commercial launch requirements during that time period.

Does anybody disagree with that statement, that if we had the fourth orbiter that you would handle all of DOD, NASA, and commercial launch requirements during that period?

Dr. **Fletcher**. Mr. Chairman, I can start out by saying that it is my impression that we could handle essentially all of them. But I can't guarantee that we could handle all of them, because we were not sure what all of the commercial payloads were and which ones were going on which launch vehicle.

But I think it is approximately true. I will ask Tommy to fill in any corrections to that statement.

Mr. **Newman**. Well, at the 24-a-year flight rate we were projecting, the answer would be correct. We were planning to fly 8 to 10 DOD missions a year, 8 to 10 NASA missions a year, and 3 or 4 commercial payload equivalent missions a year.

Mr. **Boland**. Now, if we build a fourth orbiter and have that orbiter basically in place some time in 1989, and also develop expendable launch vehicles, are there enough payloads available in the time frame I just spoke of, the time frame from 1989 through 1991, to support a viable expendable launch vehicle capability and a four-orbiter shuttle fleet?

Dr. **Fletcher**. Mr. Chairman, this is——

Mr. **Boland**. I know, Mr. Administrator, these are difficult questions, and I can understand that. But they are questions which are terribly important.

Dr. **Fletcher**. They are important, that is correct. We are working that problem very hard with the Defense Department and to the degree possible with the Department of Transportation. But, remember, because of the down time of the orbiter, which is going to be approximately 18 months, there is an accumulation of payloads that have to be worked off over time. So, because of the down time and not enough expendables during that period of time, plus the period during which we have only three orbiters, which could be 3½ years, you are going to have a backlog. It is going to take some years before that backlog is worked off. We don't have the exact answer as to how long it will take for that to happen, but it could be well into the 1990s. I should emphasize again we are still studying that problem. One of the problems is you have to guess what the payload requirements are going to be out in the early 1990 period. To the extent we are making those mission model guesses, we will come out with a more definitive answer. But it is going to take some years even with four orbiters to work off that backlog.

SHUTTLE VERSUS ELV'S

Mr. **Boland**. Let me ask you, looking at the economics of starting up an expendable launch vehicle line, such as the Delta line, and flying two or three Deltas each year, and expecting that rate will have viability as a commercial vehicle—economically, that is not very good, is it?

Dr. **Fletcher**. That is a pretty cogent question, and all I can do is give you an intuitive feeling on that. My feeling is that the shuttle is still a very cost-effective device, and once we get stabilized into a four-orbiter fleet it will be less expensive to fly on the shuttle than on any ELVs, including the Defense Department ELVs. However, there is an argument which could be made that you should have an inventory of ELVs, of some kind, in case some other difficulty happens to the shuttle at some future time. It doesn't have to be an accident as terrible as the one we just had; just a down time for the orbiters for brakes or whatever other reason.

There is an argument that says you ought to have additional expendables for the Defense Department to launch their crucial military satellites, and you could even make the argument that there are some commercial payloads that ought to have some expendable vehicles in the backlog for such an emergency, even though it is uneconomical. There is an argument which is still being thrashed through by interagency committees and so forth to go ahead with an ELV line. My intuition is that it will probably cost more to have that back-up capability.

Mr. **Boland**. That is the impression that we have, too—that it would cost more to launch them on the Delta, particularly in 1989 and 1990, and that the shuttle or Ariane could fly the payload much cheaper.

You agree with that?

Dr. **Fletcher**. That is my intuitive feeling.

We are making the study now, Mr. Chairman, and maybe Admiral Truly can give us the status of that study. But my intuitive feeling is, just making back-of-the-envelope estimates, it is still a lot cheaper to fly in the shuttle than any of the other vehicles.

LAUNCHING COMMERCIAL PAYLOADS

Mr. **Boland**. This Committee wrote to Dr. Graham not too long ago and indicated that we opposed NASA using its money to reactivate an ELV capacity. In your remarks last week, Dr. Fletcher, I heard you say that it was unlikely that NASA would be the catalyst for restarting some kind of expendable capability.

If we look at the budget requirements for NASA for its various programs, I don't know where the money would come from to reopen an expendable line, in any case.

Dr. **Fletcher**. Mr. Chairman, your comment on my comment of last week is quite accurate. We are not going to spend any NASA money for developing a commercial expendable line or any other expendable line. However, some of our customers in this interim period that are desperately in need of launching a satellite are willing to pay the cost of expendables, and under those circumstances it is conceivable that NASA might be willing to do that on an ELV. The politics are such, however, that the Department of Transportation has been given that assignment for commercial payloads. They have been given the responsibility for activities related to developing a commercial expendable launch vehicle industry. If the customer is willing to pay for it, and you can find enough customers, that can be a viable option.

Mr. **Boland**. Let me come back to a question that I asked last week concerning whether or not NASA is accepting new commercial satellite payloads for the 1989 and beyond time frame.

Dr. **Fletcher**. To the best of my knowledge, we are not accepting new commercial launches beyond that time.

Mr. **Boland**. Dr. Graham, did you want to respond? I thought that Dr. Graham has issued a memo suggesting that no new commercial satellites would be accepted for the shuttle manifest. I think you answered last week, Dr. Graham, that it was your original concept, but that you backed off from that and only applied that to a single commercial satellite, SKYNET.

Do I have that chronology correct?

Dr. **Graham**. Mr. Chairman, there was a memo released by me with that phrase in it. However, on immediate review, and before it left NASA, that memo was withdrawn. In fact, the intention of the memo all along was stated in a much better way, which was that we were unable to make a specific launch date commitment to any future customers at that time, which was February or early March.

However, during that time, and since then, NASA has maintained close communication with potential future customers. We have told them consistently that we would like to do everything possible to work with them, to see that they use U.S. launch facilities and capabilities, and that we had the entire issue of U.S. launch services under review. We would pursue a range of issues with them as the situation became clearer. So we have tried to keep those channels of communication open, tried to keep those options open. As you can realize, we are not able to commit to specific future launch dates or new commercial customers at this time.

Mr. **Boland**. But looking into the future, if it can be seen that you could make that particular commitment, do we get the assurance that NASA would accept so-called new business for the 1989 and beyond timeframe?

Dr. **Fletcher**. Mr. Chairman, I have been involved in some of those discussions, but unfortunately not all of them. We can't make that answer by ourselves because other agencies are involved. I can give you my personal opinion. I think we should, in the future, accept some payloads on the shuttle when it doesn't interfere with NASA missions and when we have room, because it is the most cost-effective way to launch commercial payloads. But particularly those payloads that are designed peculiar to the shuttle. Some of the payloads that private companies have invested money in can't be launched on other vehicles. For that case particularly, I think it would be foolish to just give them the back of our hand and say we can't launch for you any more. On the other hand, having said that, I am not sure that is the way it will all work out when we have all the other agencies involved in the decision-making.

SHUTTLE BUDGET

Mr. **Boland**. I know it is difficult to give us a definitive answer at this point in time, because of the problems you have there. But it is something that I think we have a responsibility of getting some answers to, so when we look back in the record to determine whether or not there was assurance we could handle the commercial launches, the record would state that they would be handled.

Let's talk about the shuttle budget for a moment. As you know, the Senate Appropriations Committee has included $520 million to fix the solid rocket boosters and to provide a small amount of money for what might be called production spares.

Would you characterize that $500 million-plus as being tight in terms of an estimate for the fix, or have you provided a sufficient pad to cover unanticipated increases?

Mr. **Newman**. Mr. Boland, the $526 million is probably a fairly reasonable estimate. We have provided some contingency within that amount.

Mr. **Boland**. How much is in that? What would the amount of that contingency be? How much reserve is in that $526 million?

Mr. **Newman**. At the hearing the other day, we spoke of a figure of about $626 million. Of that figure—you mentioned the $34 million that we would absorb within fiscal year 1987. There is another $56 million in fiscal year 1986 that we plan to cover within our own resources. So that $526 million plus the amounts I just mentioned would cover a total that is close to that $626 million figure.

Within that, we had about $50 million of contingency.

Mr. **Green**. Mr. Chairman?

Mr. **Boland**. Yes, Bill?

FILAMENT WOUND CASE SRM

Mr. **Green**. On this question what is the status of the filament wound solid rocket booster, the next generation. Do you have a similar problem on those?

Dr. **Fletcher**. I think we ought to turn to Admiral Truly in terms of the technical features.

Admiral **Truly**. Whatever the new design is on the SRB joint that comes out of the investigation, the redesign effort will also apply to the filament wound case.

Mr. **Green**. One concern is that the Aerospace Safety Advisory Panel raised questions in their presentation to the Senate as to the structural strength of the filament wound case for the solid rocket boosters.

Admiral **Truly**. That is true, and we have just reentered structural tests in the past week. We had a structural test where a case failed sooner than we had anticipated in the previous compression test last year. Since then, we have spent the time in the interim making sure that we had a proper plan as we go into new tests.

We have just started that test this past week, and the outcome of it will certainly give us the answers to whether or not the filament wound case is going to be safe to fly.

Mr. **Green**. Thank you, Mr. Chairman.

NUMBER OF ORBITERS NEEDED

Mr. **Boland**. Let me get back again to the orbiter in conjunction with the commercial satellites. *The Washington Post* reported last week that it was possible that the White House, in conjunction with the Senior Interagency Group, would eliminate all commercial satellites from future shuttle flights. But, at the very minimum, they would be severely restrained.

If you are not going to allow commercial satellites to fly on the shuttle, then the question arises whether or not you need a new orbiter because it seems that the fact is that the payloads are simply not there, even if you count the Space Station.

What about this?

Dr. **Fletcher**. Mr. Chairman, as I mentioned earlier, it is certainly possible that if you remove the commercial payloads and some of the DOD payloads, you could conceive of flying with a fewer number of orbiters than four. Three seems like a pretty small number for a fleet, and if anything should happen again—not a terrible accident—just a small accident—we would be in deep trouble. I guess what I am saying is that as you remember, five orbiters was the number I said we should have had. It is conceivable that we could operate with four, but three is not enough to have a viable fleet, in my opinion. I would like Admiral Truly's response to that, however. I may be off the track.

SHUTTLE MANIFEST

Mr. **Boland**. Tom Newman a moment ago indicated what the manifest was, and if you look at that manifest that was in place between the accident and 1990, it was roughly split, as I understand it, between about eight to nine military flights, eight commerical satellite flights, and eight other flights.

Is that correct, Tom?

Mr. **Newman**. In the 1990 and 1991 period——

Mr. **Boland**. From the time of the accident to 1990, eight to nine military flights?

Mr. **Newman**. Over seven years there were 56 flights, so that would be about nine.

Mr. **Boland**. What about commercial satellite flights? Eight?

Mr. **Newman**. No, there were three to five commercial satellite flights.

Mr. **Boland**. What additional satellites?

Mr. **Newman**. There would be NASA flights on the order of 8 to 10 flights, and some provision for re-flight opportunities.

Mr. **Boland**. Can it be said that the number of NASA flights through 1989 or 1990 did not average more than four flights per year? That is NASA flights, now.

Mr. **Newman**. No.

Mr. **Boland**. NASA payloads?

Mr. NEWMAN. Under the plan that was in place before the accident, the answer is no. They would have averaged 56 flights over 8 years.

REPLACEMENT ORBITER

Mr. BOLAND. One of the reasons the questions are being asked is, I presume that these were issues which were raised by the Office of Management and Budget and others in whatever White House meetings were held with NASA last Thursday. I presume these questions were raised.

Were they?

Dr. FLETCHER. Well, not in the depth that you raise them, Mr. Chairman.

Mr. GREEN. That is comforting.

Mr. BOLAND. I would not expect them to be raised in that climate.

And when you went into that meeting—I am not talking about you personally—but I am talking about the climate that seemed to exist—it seemed the general consensus was that nearly everyone agreed that a fourth orbiter was necessary?

Dr. FLETCHER. I think that is a fair description of the consensus.

Mr. BOLAND. What did Don Regan think about it?

Dr. FLETCHER. I think Don Regan was in favor of a fourth orbiter, but he was merely asking a question, and properly so, considering how much he knew about the fourth orbiter. His question was, wouldn't it be better to have a more advanced system instead of the fourth orbiter? Shouldn't we be going on to the next phase?

And I think we suggested that we were studying that problem but we are not ready to deal with it yet.

Mr. BOLAND. I don't want to create the impression that I am opposed to a fourth orbiter. All I am saying is we have a responsibility here and we would like to ask some of the questions that perhaps Don Regan was concerned about.

Mr. GREEN. Can I follow up on that particular one, Mr. Chairman?

Mr. BOLAND. Sure.

Mr. GREEN. Based on the fact that you have got this main engine wear-out problem and apparently the need for major overhaul on the order of every three years, that does raise some question as to what the lifetime of an orbiter is, and that is relevant for a number of reasons.

One, obviously it does affect cost per flight even on a marginal basis. Second, it raises the question of whether we shouldn't be looking at some intermediate shuttle system or orbiter between the present system and the time when the TAV or whatever comes onstream.

Dr. FLETCHER. Mr. Green, you are absolutely right. There are two things I want to add to that. First of all, the fourth orbiter—we call it the fourth orbiter; the official name is the replacement orbiter—will incorporate all the changes that we know about that can improve the lifetime of engines and so on. There are several of those that Admiral Truly is considering. So, the replacement orbiter should be the best orbiter. Having said that, though, we are also looking at the shuttle follow-on vehicle and there are several versions of that, not counting the National Aerospace Plane. That study is still underway, and Admiral Truly may have a better idea where it stands. But we plan to look at that.

The shuttle follow-on, cannot make it by 1989. That is farther into the future. It will be in the 1990s some time at the earliest, but still that is an important thing to look at, and we ought to deal with it as quickly as we can.

SHUTTLE FOLLOW-ON

Mr. GREEN. Again, my question is: Given the budget crunch we are facing, and knowing we will not be coming up with a happy solution, in any event, doesn't it pay to look at whether we shouldn't be moving to that rather than overlapping that with the fourth orbiter?

Dr. FLETCHER. Mr. Green, if I had a feeling that we could go with the shuttle follow-on as early as within two or three years or we could have that fourth orbiter, I would say yes, let's get on with the shuttle follow-on. But my impression is that we are nowhere near being able to make that kind of schedule.

We are talking about early to mid-1990s, Admiral Truly, are we not?

Admiral TRULY. Yes.

Mr. GREEN. "Early" would be one thing; "mid" would be another.

Dr. FLETCHER. Why don't you respond, Admiral Truly.

Admiral TRULY. My guess is that it would be the mid-1990's at the earliest, because of the technology study that we must do in order to make sure that the follow-on shuttle is the well-thought-out replacement that we are going to need. The studies that I have seen in recent weeks have dwelt not on the identification of a specific vehicle, but the identification of high pay-off technologies that we should be investing in that could be applied either to a follow-on shuttle or to an advanced ELV program or to the technology that is required for the transatmospheric vehicle.

We just are not able to decide today in what direction to move for a follow-on orbiter. There are not enough years to do that before the major crunch of the early 1990s approach us where we could still not satisfy the backlog having only three orbiters.

Mr. GREEN. I guess, again just to conclude this segment, that again I think there is something of this philosophy that you have to have a great leap forward each time and do something totally new as opposed to incrementalism in developing a program.

Dr. FLETCHER. Well, Mr. Green, we try to do both. We try to do incrementalism and so each succeeding orbiter should be a little better than the last one. I think that has been the pattern.

On the other hand, sometimes you have to stand down for a period of time and use what you have got before you take the little larger non-incremental leap. And I will just add that the thought of going from 1989 to 1996 or 1997 with only three orbiters is pretty frightening to me. It is bad enough to go with only three orbiters from 1987 to 1989.

Mr. GREEN. Thank you, Mr. Chairman.

DOD'S USE OF THE SHUTTLE

Mr. **Boland**. Let me ask the question: Given the strategic defense initiative requirements, is there any indication that the DOD would be a much larger user of the shuttle? Was there any talk about that or was there any indication from anybody that this was a possibility?

Dr. **Fletcher**. Mr. Chairman, that of course did not come up in the meeting last week. But, as you know, I know a little bit about the SDI program. It is probably true that they will be wanting a larger share of the shuttle fleet, as time goes on. We have to be careful that we don't exclude the science requirements and other DOD requirements despite that pressure.

Mr. **Boland**. If you are losing a lot of commercial satellites and the DOD is going to be a much larger user of the shuttle, why not make them pay a heck of a lot more for what they are doing? Why don't they pick up part of this tab?

I will leave it there. You don't have to answer.

Dr. **Fletcher**. That is a very good question, and I have difficulty answering it.

Mr. **Boland**. That is all right.

Mr. **Green**. Mr. Chairman, just this point, if I can express my concern again that while I know that defense needs have to be met and that this accident has created a serious problem for DOD, I would hate to see again the science segment of the program be crowded out in terms of lift capacity or in terms of the budget problems we are facing.

Dr. **Fletcher**. Mr. Green, as you know, as long as I am Administrator, that won't happen. But, as I think I indicated, I can always be relieved of my responsibilities.

USE OF EXISTING STRUCTURAL SPARES

Mr. **Boland**. Recently I think, Rockwell indicated that it could assemble a new orbiter using the existing structural spares that we have already bought for about $1.5 billion. The figure that NASA has is $1.9 billion.

What is the difference there?

Mr. **Newman**. Well, there is some contingency that we put on the Rockwell estimate. There is also inclusion in the figures of some ground support equipment, automatic check-out equipment. The three engines are included, which were not in the Rockwell estimate. The $1.9 billion includes replacement of the RMS and the space suits lost onboard. So, it is a more comprehensive estimate, and it does include contingency.

MOTHBALLING VANDENBERG

Mr. **Boland**. Now, what about the rumor that the Air Force is going to mothball Vandenberg—that costs like $2.5 billion? What does that do to the four-orbiter requirement?

Dr. **Fletcher**. As you know, Mr. Chairman, that is a rumor. We have a pretty firm commitment from the Defense Department that that will not happen. It is a hypothetical thing for us to deal with. It is still true, however, that if that worst case scenario should happen, you still need a four-orbiter fleet for the reasons I mentioned earlier. Three orbiters is just a risky proposition. It is not much of a fleet.

Mr. **Boland**. Is there any substance to the rumor that the Air Force is going to mothball Vandenberg?

Dr. **Fletcher**. Well, it is hard for me to——

Mr. **Boland**. That was not indicated to you, I take it. It is just a newspaper rumor or what?

Dr. **Fletcher**. It was a rumor, and very strong rumor, but nobody from the Air Force or the Defense Department has confirmed that rumor.

FLIGHT SCHEDULE

Mr. **Boland**. Let's talk a moment about the new orbiter. As I understand it, Admiral Truly has proposed to you a manifest based on an 18-month delay which calls for six flights in the first year, nine in the second, 12 in the third year, and 15 in the fourth.

Is that right, Admiral Truly?

Admiral **Truly**. Yes, sir.

In the outyears, what I recommend is that 12 to 15 flights are feasible, depending on the complexity of the payloads and the processing that is required. But, yes, sir, those numbers are right.

Mr. **Boland**. I understand that Rockwell has already indicated that the three orbiters cannot fly more than nine flights per year owing to a serious shortage of flight spares—do you agree with that assessment?

Admiral **Truly**. The assessment that I made was admittedly an interim one based on efforts being led by the National Shuttle Program Office Level II which include the contractors. They will do some reexamination of the logistics program so that we would be building up to those 12 to 15 flights three or four years in the future.

Mr. **Green**. Mr. Chairman?

Mr. **Boland**. Yes?

ORBITER SPACE PARTS

Mr. **Green**. What concerns me is that there have been these reports, including the reports of the Safety Advisory Panel, about the cannibalizing of parts from one shuttle to get the currently scheduled one launched—and the suggestion that since the shuttles are not identical, that this is not an ideal way to operate the program—that the whole problem—that relates the whole problem of trying to get up to the 109 percent of rated capacity and the main engine burnout.

How does this all affect the flight schedule and the time you need between flights; and what are you doing to try to deal with that problem?

Admiral **Truly**. Well, the logistics problem, including some cannibalization that had been going on in recent flights, is an important question that I have been trying to deal with.

We are setting out a course and a very important part of that is looking at that very question of cannibalization. Driving the cannibalization rate to zero is not an economical thing to do, and frankly that is not done in any airplane squadron including the warfare squadron. What you would like to do, however, is make sure, first of all, you are not endangering safety by taking out flight critical parts and increasing the safety risk by cannibalizing in that fashion. An example would be increased traffic in certain confined areas of the shuttle, such as the engine area—you would not like to do that. So, what we are doing is taking a look across the orbiter spare parts to determine where to best invest our money in hardware spares on the shelf so that we reduce cannibalization, but not to zero. That is not really a practical thing to do, and I don't think anybody would recommend that because it would require so many spares that it would just not be necessary.

So, part of this logistics planning that we are doing during the down time includes that, and we hope to see a marked improvement when we get back to flying.

HEAVY LIFT PAYLOADS

Mr. **Green**. I gather getting to 109 percent is essential for some of your payloads?

Admiral **Truly**. There are performance questions of which the 109 percent is one of the performance answers to get some of the heavy payloads airborne. We have done a great deal of single-engine testing at 109 percent. Prior to the accident, there was a three-engine main propulsion test scheduled early in 1986.

We also had run, just prior to the accident, into some early indications of some turbine blade cracking problems that we are taking action on. This has made us want to do some more single-engine testing this year. So we have put off that three-engine 109 percent test until the earliest, I believe, is January or February of 1987.

Mr. **Green**. Is there any other way to deal with these heaviest loads other than by getting to 109 percent?

Admiral **Truly**. There are several things that you can do. The filament wound case and the 109 percent helps us with performance. There are also some analytical studies that we are investing in that would allow us, if they turn out to be proper, to fly the ascent profiles in such a way that we would get out of the dense atmosphere a little quicker and gain some performance that way. Those are the ones I like the most. Because they don't require hardware change, and essentially would show that as we operate we are learning more about the vehicle and being able to fly it in more efficient ways. So there is no easy answer to your question. We are pursuing a number of things on performance, and 109 percent is one of them.

Mr. **Green**. Thank you, Mr. Chairman.

BUDGET CHANGES RESULTING FROM THE ACCIDENT

Mr. **Boland**. Looking again at this table, Tom, with the changes resulting as a result of the accident—this is a table that is not in the justifications—my understanding is that this table was put together based on a 12-month slip in shuttle flights.

Is that correct?

Mr. **Newman**. That is correct.

Mr. **Boland**. I understand the current baseline 18-month slip would change the shuttle operations line some, but that the net difference between savings of $288 million and reimbursement losses of $159 million would still be about the same.

Is that correct?

Mr. **Newman**. Based on the analysis we did, that is correct.

Mr. **Boland**. What if there were a two-year slip? Would that produce more net savings or less?

Mr. **Newman**. I would really have to work that out. It does depend on the assumptions you make about reimbursible customers versus NASA missions. I don't have a ready answer to that.

Mr. **Boland**. You may supply it for the record.

[The information follows:]

A twelve-month gap in STS flights was projected to provide a net savings of $129 million to FY 1987 Shuttle operations funding requirements. This estimated net savings resulted from a $288 million reduction in cost requirements partially offset by the $159 million loss of anticipated reimbursements from commercial customers. The revised budget plan applied these savings to fund corrective actions in the STS recovery plan such as the Solid Rocket Booster redesign and requalification. The possible extension of the downtime to two years would be driven by a potential increase in the scope of recovery activities. Preliminary estimates are that such an extension would reduce total funding requirements for Shuttle operations by an additional $250 million of which about $200 million would probably be required to offset loss of reimbursements and refunds to customers for prior year payments. The actual amounts required are unknown at this time and would be a result of individual decisions by customers. If the above figures prove to be approximately correct, net savings of about $50 million would be available to fund the increased costs of redesign and recovery efforts that caused the extended delay.

SUPPLEMENTAL

Mr. **Boland**. If the Urgent Supplemental does not become law in the immediate timeframe—and by that I mean some time before the July recess—I am wondering when you will need a reprogramming of funds from other NASA programs to fix the SRBs?

Dr. **Fletcher**. Mr. Chairman, that is such a horrible thought that I don't like to contemplate it. We would have to start by mid-June, do something, maybe early June.

Mr. **Boland**. So, those requirements would become critical?

Dr. **Fletcher**. Yes, indeed.

Mr. **Boland**. In the May/middle June—well, this month—time frame?

Dr. **Fletcher**. If it didn't happen, say, in early or mid-June, we would just not make our schedule.

Mr. **Green**. Mr. Chairman?

Mr. **Boland**. Mr. Green.

Mr. **Green**. Has Marshall either formally or informally committed NASA to a fix effort by Morton Thiokol?

Mr. **Newman**. There is not a contract on that. They have been authorized to do design work. They are supporting the investigation and test effort. They have developed a plan as to how the fix would be pursued, but they have not been authorized to implement that plan.

Mr. **Green**. Would any action authorizing them to do that require a reprogramming?

Mr. **Newman**. Well, we mentioned that we had provided about $56 million in fiscal year 1986 to begin work on the areas I have just described. Now that does not include implementing the plan. To actually implement the plan would require funding either from the urgent supplemental action or if necessary we would have to consider other resources.

Mr. **Green**. If you didn't get the Urgent Supplemental you would acknowledge you would need to submit a reprogramming?

Dr. **Fletcher**. Or we could conceivably, Mr. Green, slip the date on the completion of the SRB redesign effort.

Mr. **Green**. Thank you, Mr. Chairman.

SRM TEST FIRINGS

Mr. **Boland**. Let me ask you, Admiral Truly, with reference to the schedule and anticipated completion of the static firings of the re-worked solid rocket booster joints. Do you have a schedule on that? When will that be completed?

Admiral **Truly**. Let me make sure I understand your question. When will the refirings be scheduled?

Mr. **Boland**. No. When does the schedule anticipate completing the static firings of the re-worked solid rocket boosters?

Admiral **Truly**. The July 1987 schedule that we are on, as I mentioned last week, is a success schedule and the full scale motor firings would go essentially right up to flight date with, naturally, time after the final qualification firing to take the booster apart and examine it so we understood the results of the test.

But essentially the last portion of the test schedule would be in parallel with the buildup of flight cases.

Mr. **Boland**. So if there was a delay in the test schedule, there would be a delay of the launch in July.

Admiral **Truly**. Yes, sir.

SHUTTLE CENTAUR

Mr. **Boland**. Let's talk a little bit about the shuttle/Centaur program. That is reflected on pages RD-2-1 through RD-2-9, but I think you can answer the pages questions without following the justification itself.

Those numbers in that particular table reflected on pages RD-1 through 9 are no longer accurate owing to the accident, and owing to the continued overrun of the shuttle/Centaur program.

As you know, we have discussed this program briefly last week. We discussed it at length in days gone by—I guess over about a five-year period. This Committee believed in that concept because it provided the most capability for the Defense Department, and the most capability to the planetary program.

Is there any disagreement with that, particularly the planetary program and some of the DoD launches?

Dr. **Fletcher**. Mr. Chairman, your statement is true. On the other hand, it is a fairly advanced technology that we are dealing with and there are safety issues that have to be dealt with, which I am sure Mr. Truly can recapitulate for you if you like.

PLANETARY MISSIONS ON THE CENTAUR

Mr. **Boland**. This Committee first recommended flying Galileo on the Centuar back in 1979. I don't think that either the agency or all of the other three major committees involved with NASA were very happy with that. But that particular opinion changed not only within the agency itself, but also within the Congress.

This Committee is disappointed that General Dynamics did not put in the kind of resources at the outset of this program which were necessary to ensure that it would meet the May 1986 launch dates for Galileo and Ulysses. At the same time, however, it should be noted that our Investigative Staff clearly pointed out that the Johnson Space Center was negligent in not providing General Dynamics and the Lewis Research Center with sufficient safety requirements before the program had reached a point that those safety requirements were very difficult to work into the schedule.

I don't think that the Johnson Space Center ever supported the program anyway, or ever favored the program, but I am not indicating that that delay was intentional.

In any case, we will never know whether the Centaur would have been ready for the May launch. I believe Admiral Truly said last week that he did not believe the Centaur would have been ready. What the Subcommittee does believe, however, is that it makes no sense to spend money at a continuing high rate necessitated by both additional overrun requirements and, of course, the delay imposed by the accident, unless all who are credible players in this program, and that means the Safety Advisory Committee, the astronauts, NASA's own technical people—unless they all are willing to step forward and indicate that the program is safe and can be flown safely in the shuttle bay.

It is for that reason that we have asked our Investigative Staff to give us an assessment of the feelings of that community. We expect to get that assessment back on or about May 30, and shortly after that we will make a decision concerning whether this program will proceed.

I know Admiral Truly, that you indicated that you had your own investigation under way and that it would report sometime in the future.

Admiral **Truly**. Yes.

CENTAUR SAFETY

Mr. **Boland**. I must tell you that I think waiting four, five, or six months does not seem to make economic sense, and I would hope that we would not have to wait that long.

And until we can all agree that unless we get a green light on the safety issue in the next 30 days it does not make sense to proceed with this program. Anybody want to respond to that?

Dr. **Fletcher**. That is a pretty bold statement, Mr. Chairman. I would rather put it the other way, that we are not going to fly the Centaur until it is safe, but we think it can be made safe. And whatever it takes, we hope to come before you and tell what it takes to make it safe. That is what Admiral Truly is trying to do at this point.

Mr. **Boland.** What about the five or six month investigation, Admiral?

Admiral **Truly.** I think I may have confused you when I testified last time. What I meant to say was that we do have an ongoing effort on safety that includes an independent safety examination of Centaur. That examination is planned to be in great depth and will take many months over the remainder of this year. Because of the things that you said and the interest and our need to know whether or not we are on the right course, I have started a review, the results of which will come to me at my level in the next week or so. The questions that I think should be asked are these: Will the total shuttle Centaur system, given the successful incorporation and completion of planned enhancements, be safe to fly? What is the estimated cost? When will Centaur be ready to fly?

The examination which is directed to the NASA centers will involve the support of the community. It is in work at the moment.

As quickly as I can, depending on the outcome at the program level, I intend to take the information I can to the Administrator so that he can properly respond to you.

Mr. **Boland.** We appreciate that comment. All is not lost because money has been spent on the Centaur program. That Centaur will be used on the Titan 34-D7, I think.

Admiral **Truly.** Programmatically we are doing nothing—despite this review—to assume that the enhancements that we have already identified, that are needed, are continuing at an engineering level. We are not committing long-term fabrication money.

What we are doing now is doing planning, assuming that if the program is to proceed, we will be able to continue.

CENTAUR COST

Mr. **Boland.** Dr. Graham, in your letter to me of April 23, you indicated that the additional requirements for Centaur would run $160 to $180 million above the level budgeted in fiscal year 1987. That figure represents the runout, including requirements for 1987.

The March 10 table indicates that the upper stage budget will increase from the $85 million carried in RD-2-1 by $91 million to a total of about $176 million. Is that estimate still holding?

Dr. **Graham.** Mr. Chairman, I would make a general comment now and ask Mr. Newman to address the details of it.

Those were our best estimates at the time of what we thought would be required. At that time, however, I did ask for a more detailed analysis and that is in fact the process which Admiral Truly just described.

So we are still reviewing those figures to see if they are in fact accurate and comprehensive. With that let me ask Mr. Newman to comment.

Mr. **Newman.** Mr. Chairman, the $91 million that we show on the table is consistent with the increase of $130 million, which we had discussed, for the specifically known increases. At that time we said there was a potential of further increase of $30 to $50 million and that is not reflected in the table you have been looking at.

COST OF TERMINATING CENTAUR

Mr. **Boland**. Can you tell me, Tom, what it would cost if we make a decision, let's say in the next 30 days or 60 days, and advise the agency of that decision that in view of the uncertainties of the safety situation, that the program ought to be terminated.

What would we save?

Dr. **Fletcher**. There are two questions that I think we better answer first. That is if such a dire thing happened, how much would be saved? We haven't answered that.

Mr. **Newman**. The estimate of the termination cost depends on what the Air Force does about using the Centaur on ELVs. Assuming they do not pick up that option, we believe the termination costs would be in the $60 to $75 million range.

Mr. **Boland**. Less than the $91 million you provided for in this table, though.

Mr. **Newman**. That is correct.

Mr. **Boland**. Okay.

Dr. **Fletcher**. The reason I say there are two questions involved, Mr. Chairman, is that we would have to do something about Galileo and Ulysses and some of the other programs as well as the Defense Department programs. And the only thing I could think of is we would have to use those 34-D7 Titans for science programs. I don't think we have made an estimate of the cost of that, but that would really be a problem.

PROCUREMENT AT NEW ELV'S

Mr. **Boland**. Let me ask you, Tom, are there any funds in the revised 1987 table under Upper Stages included for the procurement or for development of any new expendable launch vehicles?

Mr. **Newman**. No, not for ELVs.

Mr. **Boland**. Are there any reprogrammings being considered to use any NASA funds for such an activity?

Mr. **Newman**. We don't have any plans at present to do that.

ORBITAL TRANSFER VEHICLE

Mr. **Boland**. On page RD-2-1, this would be the Space Transportation and Capability Development area. Look at the advanced programs reflected on page 17.

You are requesting $16,600,000 for that activity in 1987. How much of that is programmed for the Orbital Transfer Vehicle?

Dr. **Fletcher**. I don't believe, Mr. Chairman, very much is going into the OTV as we call it. We may have a slight amount of study money in there. We are considering of course an Orbital Maneuvering Vehicle and either John Hodge or Tommy should answer that.

Mr. **Newman**. I would like to check this—but I believe there is about $1.3 million of that $16.6 on the OTV.

Mr. **Boland**. Will you break out the remainder for the record.

Mr. **Newman**. Yes, sir.

[The information follows:]

ADVANCED PROGRAMS FY 1987 CONGRESSIONAL BUDGET

[Dollars in millions]

	Fiscal year—	
	1986	1987
Total	21.0	16.6
Satellite services: Includes feasibility studies for future EVA tools and equipment, flight demo concepts definition, automated rendezvous and proximity operations, spacecraft services and remote workstations and mission kits for the OMV	4.0	4.3
Spacecraft systems: Includes conceptual studies of unmanned platforms, including geostationary platforms, servicing of remote platforms, applications for advanced tether platforms and the telepresence workstation	3.0	3.0
Advanced transportation: Includes conceptual studies of the next generation Shuttle and Shuttle-derived Heavy Lift/Tanker vehicle, the Orbit Transfer Vehicle, manned GEO capability, and advanced recovery/reentry systems	4.0	4.3
Advanced crew systems: Includes feasibility studies on long duration EVA, high mobility suit components, ECLSS for long duration missions, advanced development gloves, and advanced food-habitability systems	2.0	2.0
Advanced missions/advanced development: Includes Phase B study on aeroassist demo definition (FY 1986), long range planning, conceptual studies on capture analysis	6.0	1.0
Generic: Includes conceptual studies on space construction and assembly, orbital debris management and advanced ground systems	2.0	2.0

TETHERED SATELLITE

Mr. **Boland**. On page 2-19 now.

On the Tethered Satellite System program, you are requesting $11,600,000 in 1987, and that was based on a flight in 1988 aboard the shuttle. I suspect that that item could be reduced some. Is the flight carried in 1988 in the revised manifest?

Dr. **Fletcher**. We don't have a revised manifest, Mr. Chairman. That is still under advisement.

Mr. **Boland**. All right.

Can this line item be reduced at all?

Mr. **Newman**. We had not planned to reduce that in the table that we gave you. However, if the flight is significantly delayed we would have to look at that again.

Mr. **Boland**. And——

Dr. **Fletcher**. It is fair to say that is a possible saving, Mr. Chairman.

Mr. **Newman**. We had taken some funding out of that in fiscal year 1986 so that where you see the $17.5 million in fiscal year 1986, we have reduced that to $15 million.

ORBITAL MANEUVERING VEHICLE

Mr. **Boland**. On page RD-2-20 you are asking for $70 million for the Orbital Maneuvering Vehicle. Last year's reduction from $25 million to $10 million delayed the first flight from 1990 to 1991. When is the OMV required to reboost the space telescope, based on your current assessment of the launch of the telescope and its assumed orbit degradation?

Dr. **Fletcher**. Mr. Chairman, that depends to some extent on when the telescope gets launched. I am not sure of that. Burt, can you answer that question?

Dr. **Edelson**. Two-and-a-half years after launch is our planning figure, Mr. Chairman.

Dr. **Fletcher**. That is part of the manifest that is still uncertain.

Mr. **Boland**. What is your first requirement for the OMV for the Space Station? What year?

Dr. **Fletcher**. Mr. Hodge.

Mr. **Hodge**. We had planned to use it as soon as the Space Station was up there.

Mr. **Boland**. I am asking what year you think you will be using the OMV?

Mr. **Hodge**. Probably during 1996.

Mr. **Boland**. In the revised———

Mr. **Newman**. May I make another point on the OMV. In the adjustments that we gave you for fiscal year 1987 we plan to take $20 million out of the $70 million leading to a revised delivery date of September 1991.

Mr. **Boland**. Can it be further reduced? I know this indicated a $20 million reduction, but can it be further reduced by more than $20 million in this activity?

Mr. **Newman**. We are hesitant to do that because we have already delayed the delivery date to September 1991.

BUDGET REQUEST FOR SPACE STATION

Mr. **Boland**. Turn to the Space Station which begins on page RD-1-1. On that page we see you request $410 million in 1987, of which $260 million is earmarked to complete the Phase B definition; is that correct?

Mr. **Hodge**. Yes, sir.

Mr. **Boland**. And now you are requesting $150 million to institute development, is that correct?

Mr. **Hodge**. Yes, sir.

Mr. **Boland**. How much of that $150 million actually would be obligated in fiscal year 1987? I think you may not be able to answer some of these questions right here.

Mr. **Hodge**. I see no reason why we should not be able to obligate all that money. That is split into three pieces, $90 million of that is for the hardware contractors, the four work packages, $30 million of that is for the Software Support Environment program that we have talked to the staff about and $30 million is for system engineering support.

The $60 million would be obligated very early, the $90 million would be obligated toward the middle of the year.

Mr. **Boland**. What was your original request to OMB for this program?

Mr. **Hodge**. We had originally asked for $600 million total.

Mr. **Boland**. And where did the reduction from $600 to $410 million occur?

Mr. **Hodge**. We took it out of both definition and development. There was a reduction from $270 to $150 million for the development and then we reduced the definition funds in two areas. First of all, we took it out of the advanced development technology area by really selecting less sophisticated technology.

Mr. **Boland**. What was the reduction in the development line again?

Mr. **Hodge**. From $270 to $150 million.

Mr. **Boland**. Was that a recommendation by OMB or was it your recommendation?

Mr. **Hodge**. It was a compromise. Mr. Culbertson might like to elaborate.

Mr. **Culbertson**. It was a compromise, the top figure was OMB's, the way we handled it was ours.

Mr. **Hodge**. Yes.

SPACE STATION BASELINE CONFIGURATION

Mr. **Boland**. The indication last week was that NASA had proposed a baseline definition for a permanently manned Space Station that included certain functional requirements, one of which was a life science module. My understanding is that the cost of that baseline configuration was approximately $12 to $13 billion dollars.

One way or another what NASA then did was to rescope the program and attempt to squeeze it within an $8 billion figure, expressed in 1984 dollars. Is that correct?

Mr. **Hodge**. Yes, sir.

Mr. **Boland**. My understanding is that you were able to do that by eliminating two of the four modules in such a way that the total volume of the four modules is not significantly reduced. Is that correct?

Mr. **Hodge**. Yes.

Mr. **Boland**. I would like to have you indicate for us, and I would like specifics of it, what exactly was the delta, the difference, between the $13 billion estimate that came in last summer and the $8 billion estimate today. How were you able to cut $5 billion from the baseline Station?

Mr. **Hodge**. The biggest problem we had as we started to look at that sort of data was that there were a number of overlaps between each of the work packages, that were deliberately put in there. They had to be taken out as a part of the effort to scrub the estimate back tc a reasonable number.

In addition to that, we had a problem associated with the level of technology which the contractors had used to estimate the cost of the program. As the cost models work, the base information is related to the cost of the subsystems themselves. What we discovered was that the level of technology being assumed was considerably higher than required to meet the requirements of the users. Let me give you an example of that. The accuracy of the pointing systems was an order of magnitude more accurate than was required for the pointing systems that the science and applications people were asking for. So we were able to reduce the overall requirements on the system and that, in turn, reduced the cost of the system.

Now, when you put all those together, there was a very significant reduction in the cost of the technology and the subsystems for the Space Station, and since everything else multiplies on top of that, that resulted in a direct percentage reduction for the whole program. So that was the first thing that we were able to do to reduce the cost. That amounted to, as I recall, well over $2 billion in the overall reduction of the program.

The next thing we had to do was to see whether or not all of the systems that were being provided were needed in the program. In other words, was there something we could take out of the program? You mentioned the fact that we went from the four modules that were designated at the beginning, to two modules that had essentially the same volume as before. That also provided a reduction in the overall cost of the program.

And then we went through the costs that the contractors have to apply to the subsystems in order to do the systems engineering and integration resulting from their particular piece of the program. And we were able to take out, about 20 percent of the cost of what they were doing by simply taking out some of the specification requirements that we felt were overspecified, and by very carefully annotating the contractor's test and evaluation sequences.

Mr. BOLAND. Will you attach a dollar figure to all you are talking about, to the specific actions you took?

Mr. HODGE. Yes, I can.

Mr. BOLAND. Supply it for the record.

[The information follows:]

Mr. Chairman, let me first point out that the $12–13 billion estimate that you have referred to represents preliminary cost estimates from a number of contractors and from staff at the Johnson Space Center. Purposefully included in these estimates were overlaps in Space Station requirements. The estimates also tended to incorporate substantially higher levels of technology that we felt were required to achieve the program goals. These overlaps and additional technology costs were "scrubbed out" in our analysis of these initial cost estimates with the result that we were able to reduce the cost of the Space Station to the approximately $8 billion that we have proposed in our budget.

There were several areas where we were able to achieve significant savings. The first areas involves hardware deferrals. By considering the extent of the proposed international participation, increasing the size of the basic common module, and utilizing previously developed hardware, approximately $1.8 billion worth of hardware was removed from the baseline configuration while retaining nearly the same of internal volume.

The next area can be characterized as content and/or hardware revisions. All of the major Space Station subsystems were carefully reevaluated to determine the extent to which capabilities satisfied user requirements, and the appropriate adjustments were made. As I indicated, in many cases, the subsystems oversupported the requirements, and considerable savings were realized. In addition, the reduction in the number of modules and changes in the concept of the logistics modules enable the program to reduct the connecting hardware and outfitting efforts substantially. The uncertainty of some aspects of international participation led to the addition of another U.S. platform and other hardware. Finally, to retain certain hardware and technology options, the addition of some funds was required. In total, content and/or hardware revisions accounted for a net reduction of approximately $1.2 billion.

The final series of actions can be categorized as program management revisions. The development contractors have indicated that employing new ways of doing business will result in substantial savings to the program. The program also elected to assume additional non-safety-related programmatic risk by reducing the level of reserves to be maintained. These actions resulted in the savings of approximately $800 million.

SPACE STATION EQUIPMENT

Mr. BOLAND. There is some question whether or not that the $8 billion is seriously underestimated.

Mr. HODGE. Yes.

Mr. BOLAND. It is, is it?

Mr. HODGE. No. I can understand there would be a question.

Dr. FLETCHER. On the other hand, Mr. Chairman, the $8 billion is our best guess as of now. We have not really completed the Phase B studies so it might be up a little or down a little when we get through by the end of this year.

Mr. BOLAND. I would like to find out because I think this is a question that has to be answered to determine whether or not the scenario ought to proceed, and whether or not what you are buying with $8 billion doesn't commit funds to operate or do useful experiments in the station.

First of all, I believe that you have to include what is known as generic Space Station equipment, is that correct?

Mr. HODGE. Correct.

Mr. BOLAND. My understanding is that only a part of that generic equipment will be paid out of the $8 billion and part will be paid out of the Office of Space Science and Appropriations budget. Is that correct?

Mr. HODGE. Yes.

Mr. BOLAND. Why is that so?

Mr. HODGE. We agreed when we put the program together in the first place that the characterization of the Space Station program would be to provide a facility. Now the question that had to be asked was how much generic equipment would be contained in such a facility. We left that open because we have to be very careful that we don't provide equipment that in fact the general user does not want or would not normally use.

We have just started the process of working with all of our user communities to see how much of that general purpose equipment would be a reasonable thing to provide. Now what we have discovered is that the user community would rather provide their own equipment than have it provided in the general lab sense.

Mr. BOLAND. They would rather provide their own ordinary equipment.

Mr. HODGE. Yes, sir. We have characterized that in five different kinds of equipment that we are looking at right now, and we are working with Dr. Edelson's people and Dr. Colladay's people to see what is the proper balance between that provided by the Space Station Program and that provided by the user community.

Mr. BOLAND. What is the total generic equipment requirement of the Space Station, in dollars?

Mr. HODGE. In dollars, at the moment we are using a number of about $360 million. I think that if you take it all the way down to the very specific equipment that a user would require it could be upwards of a billion dollars.

Mr. BOLAND. How much of that is paid from within the $8 billion figure?

Mr. HODGE. $360 million, as I say.

Mr. BOLAND. How much is paid from the foreign contribution?

Mr. HODGE. We really have not been able to separate that from their level of detailed design at the moment; it has not been possible for us to determine the amount of money which they are proposing to put into their program in order to provide generic equipment. That will be the subject of the preliminary design effort going on over the next 8 to 10 months.

Mr. **Boland**. And whether or not there are other areas of the NASA budget that are impacted by the cost of this generic equipment?

Mr. **Hodge**. Sorry, would you—I didn't quite get that.

Mr. **Boland**. How much comes from other areas of the NASA budget to pay for this program?

Mr. **Hodge**. It really is a definition problem.

Mr. **Boland**. Can you indicate, can we get some answer to that or——

Mr. **Hodge**. I can get some number for you of that kind.

Dr. **Fletcher**. A lot of that is not pinned down, Mr. Chairman, so we would be making some guesses on that.

[The information follows:]

NASA has currently identified approximately $360 million within the estimated $8 billion Space Station Program for generic equipment, although a more precise and operational definition of generic equipment is being developed so that more definitive funding requirements for such equipment can be identified. The current plan is to develop an operational definition and an agency funding strategy for generic equipment by this September. This will allow appropriate input to the Phase C/D RFP and to the budget planning activities for user sponsors for FY 1988.

Mr. **Hodge**. The trouble is as you start to look at the experiments—Dr. Edelson really isn't going to go into his Announcement of Opportunity process until next year and will not really be funded until the following year. It isn't until that has been done that we can tell how much generic equipment will be required out of his budget.

Mr. **Green**. What troubles me about this whole process is that we are building a Station and then deciding what it is going to be used for instead of something to be used to achieve some purpose.

Mr. **Hodge**. I understand the problem there and there is a sort of "Catch-22" in that process, but this is really the nature of building a facility in any case. You build a facility with a bounded capability in order to do what you believe you are going to want to do in that timeframe. It is like building a wind tunnel in 1932 and using that same wind tunnel to do the low speed tests on the supersonic airplane that you have not designed yet, but that is exactly the characteristics we are looking for. We are looking for a facility that has a bounded capability that the users will be able to use within that bounded capability. It is the classic dilemma of designing a facility. And not a space problem.

Dr. **Graham**. If I could add something. We don't want to leave you with the impression, Mr. Green, that we have not done a great deal of work with the users. In fact, user requirements have been one of the driving considerations in the Space Station design from the outset and are still very much in the forefront of our requirements and specifications for the Space Station.

We have an extensive set of user requirements that we are comparing with the capabilities that we are developing. Some of these requirements are evolution of Spacelab payloads, for example, others come from the scientific community, some from the commercial community. So we are very, very aware of the need for using the station in a productive way and we are taking specific and concrete steps to keep the design in close synchronization with user requirements.

SPACE STATION OPERATIONS COSTS

Mr. **Green**. Do you have any figures as to what it will cost to operate the Station first in the man-tended mode and then in the permanently manned mode during the early years of its operations?

Dr. **Fletcher**. I think we do, Mr. Green.

Mr. **Hodge**. We have made a general estimate of the cost of operating the Space Station in the mature phase once we put everything out there, that is, the fully manned baseline reference. What we did first of all was to put together a list of those things that we will classify as operations, the definition of this process is very important to start with. And we did that in the report which we sent to Congress earlier this year. What we did was to calculate how much it would cost to operate that baseline configuration within that definition, and I think it is all encompassing. That analysis indicated that if we do not change the way we operate right now, in other words if we were to use the same capability of facilities and processes that we have at the Cape and Goddard and so on, it would be between $1 billion and $1.5 billion per year.

OPERATIONS COSTS IN MAN-TENDED MODE

Mr. **Green**. What would the cost be in the man-tended mode?

Mr. **Hodge**. It is not clear that there would be a significant reduction because in fact to operate efficiently in the man-tended mode, you really have to have more shuttle flights. The problem you have in the man-tended mode is that you are talking about a maximum of ten days per mission and if you only operate the four flights per year for the system that we would normally be putting in a fully manned operation, then that gives you very low utilization, particularly in the pressurized volumes.

Mr. **Green**. That is assuming you don't leave experiments up there that are the kind that don't have to be man-tended but that can function between launches.

Mr. **Hodge**. That is true. We have looked at that particular issue and there are a number of instruments that are in the external attached mode that can be operated in a continuous way. But when you go inside the pressurized modules which is where the majority of the new technology and new science are being looked at, it is the presence of the man there which allows you to do the experimental sciences as opposed to the observational sciences. In fact, what you find is that the things you can do on the Space Station in the man-tended mode inside the pressurized modules, which is the experimental mode, are essentially the same as we can do right now in the Spacelab.

Mr. **Green**. I would assume that, but I would assume there are other experiments that you don't have to have tended but that you could leave out there.

Mr. **Hodge**. In the pressurized volume it is unclear at the moment. We have examined that and there do not seem to be very many in the data base which could be left unattended for long periods of time.

POWER REQUIREMENTS FOR MAN-TENDED MODE

Mr. GREEN. The other criticism I hear is that you have provided inadequate electric supply in the man-tended phase and your schedule does not move much up in the man-tended phase.

Mr. HODGE. Well, the engineering people have done a lot of imaginative work in order to get the man-tended phase and fully manned phase into the launch schedule. If I remember the numbers correctly now, after the sixth launch we will have a man-tended capability.

Mr. GREEN. But you don't have your logistics up for it until you have the crew there and you are permanently manned.

Mr. HODGE. That is because the process we put together right now is on the assumption we will go straight through the schedule to a fully-manned configuration. What that launch schedule allows you to do is to pause at the man-tended version if you want to. That particular launch schedule could stop at the sixth launch and you could work with logistics flights for the man-tended mode at that time. That is not our plan at the moment.

Mr. GREEN. If we are going to leave a possibility in, for whatever reason, shouldn't one have more of the electric supply available, at least half power?

Mr. HODGE. Well, that is a question that we would have to look to when we finally conclude whether or not we are going to pause at the man-tended phase. At the moment we have done studies on the amounts of photovoltaic power supplied compared to the solar-dynamic power supplied, on the basis of a reasonable tradeoff in the design of the Space Station between the level of power needed and the relationship between the manned base and the unmanned platforms because we are intending to use identical photovoltaic systems for the platform that we have on the Space Station.

That came out to about 6.5 kilowatts, so it seemed reasonable to use a 25 kilowatt stepping point there. If we decide to pause at the man-tended phase, we could, in about two years, make that decision and put more power in if it was appropriate to do so.

Remember, we put that set of launches together in order to optimize the move towards the 1994 presidential requirement that we have to have a fully manned system. It makes sense to do it on that basis. But we did allow the capability in the design process to pause at the man-tended mode if necessary, and that will of course result in missing the Presidential edict. And we must make those decisions by 1989.

TIMEFRAME FOR DECISION ON POWER REQUIREMENTS

Mr. GREEN. At what time, so I understand—as I read this, you reach the man-tended level at August 1993. If you wanted to have more electric power available at that time—not the 25, but, say, 37½—at what time would you have to make that decision?

Mr. HODGE. In about two to three years.

Mr. GREEN. You would have to make this decision in 1988?

Mr. HODGE. Yes.

As a result of that, we would make a less efficient decision on the addition of power at a later time, because we are looking at what is a reasonable size for the photovoltaic, and it looks like 25 kw per system is a reasonable amount to do.

If you put all photovoltaic power, which is the way you would do what you suggest, you would end up with more power total, but it would cost more.

Mr. **Culbertson**. Mr. Green, if I can add another comment, the plan that we have for pausing at the man-tended capability, which Mr. Hodge refers to, will require a decision from the standpoint of the users before the date that you would intend to make the pause. That decision is required because the requirements of the suppliers of the equipment, which will be the responsibility of the user will change somewhat if we do go through a period of a couple years in the man-tended configuration. What I am saying is that the planning of the users for the fully manned Space Station will deliver one set of hardware, but it will have to be modified somewhat before it would be useful in the man-tended configuration. That will require the lead time to do the kind of thing Mr. Hodge has suggested.

The other thing is that, as we looked at the possible uses of the Space Station in that man-tended period, the big power users were not shown to be highly effective during the man-tended portion of the program.

USER REQUIREMENTS FOR POWER IN MAN-TENDED MODE

Mr. **Green**. We have had some indication from the contractors that if it was just the 25, you have nothing.

Mr. **Culbertson**. Certainly, if we don't have any power for the user with 25, then we are in complete agreement. So the question is, how much power will the basic Space Station have? That is going to have to be worked out in the final stages of preliminary design.

If I could, Mr. Chairman, I would like to make one other comment in response to an earlier question by Mr. Green that had to do with the definition of generic equipment and whether we were building the Space Station and then looking for users.

About two years ago, NASA set up a committee, which all of us have referred to as the Peter Banks Committee, the Task Force for the Scientific Uses of the Space Station, and they have very, very conscientiously, in great detail, specified the type of thing which scientists will be expecting to do in space. But the fact that we have not been able to identify all of the individual pieces of equipment which those scientists will want to have does not mean that there has not been the kind of effort which tells us how the system will be used. That next level of detail will be identified when specific users are selected. That has not been done yet because it is not appropriate yet to be getting users that deeply involved eight years before the system will fly.

Mr. **Hodge**. It may be appropriate to ask Dr. Edelson to talk about the process that he used for selecting experiments for missions that are this far in advance.

Dr. **Edelson**. I think I may be helpful, Mr. Chairman, in addressing this from the user's point of view.

The science and applications program is likely to be one of the biggest users, and certainly, at the present time, one of the more active and enthusiastic potential users of the Space Station. I would say that the situation is far from one in which the Space Station is being developed first and later seeking how it might be used by users.

I would characterize the situation as quite the reverse, in which the science and applications community has pursued a significant planning process over the last two years in which we have looked at various disciplines—astrophysics, earth observation, microgravity science, life science, et cetera—and ascertained how each of those disciplines might benefit from the Space Station and its facilities. Then through the use of advisory committees—of which the Task Force on Scientific Uses of the Space Station, the so-called Banks Committee, is just one—we have identified and recommended various uses.

What my office has done in turn is to evaluate those in terms of contribution to the program, prioritize them, and publish them in significant detail in various publications that we have put out. Then we transmitted them to the Space Station Program office—first Mr. Culbertson and now Mr. Hodge. And I believe I can say that the fact that we have in the program plans for significant requirement, like repair and servicing of the Hubble Space Telescope and other astrophysics instruments, polar orbiting platforms and co-orbiting platforms, and the general requirements for the laboratory modules, are directly due to the studies that we have done and the influence we have had.

I would say this from a personal point of view, as the titular leader of a space science community within NASA. I had to decide early on, perhaps three years ago, whether it would be desirable to support the Space Station Program and try to influence it to be good for science and applications, or to join with a number of the spokesmen of the science community who felt that the Space Station would be a threat to continued health of the science program. I took the former course, and I think I have led a very active role in doing that.

Now, to get specifically to the questions that Mr. Green was asking about the man-tended Space Station and the laboratory power and so on, we have prioritized our requirements in such a way for the manned Space Station in a fully manned situation and from the man-tended situation and for the platforms such that the program office can start at the top and work its way down depending on how much money they have; in all of those cases they, as far as I can tell, have been scrupulous in following our priorities. We would be very pleased to have the program proceed on that basis and with the facilities provided that are in the current plan.

SPACE STATION POLAR PLATFORM

Mr. GREEN. Let me ask: Mention has been made of the polar orbiting part of the Station. Obviously, that has to be man-tended, when it is going off on a different orbit.

If it should be necessary to stretch out funding for the development of the Station, what is the possibility that that could be developed first and operated in the man-tended mode?

Mr. HODGE. The way we have put that launch schedule together really allows the launch schedule for both the polar platforms—not so much the co-orbiting platform because it would have to be tended by the Space Station—to be modified with time. There is no question that the polar platforms could come in earlier. But, again, it is a question of meeting the requirements of the users. There is no point in putting the polar platform up there if science and applications program is not prepared—with instruments in the budget. So they have to be worked in parallel with each other.

I should say there may be another polar platform going up which is being provided by ESA, and it, too, will be scheduled in accordance with the availability of the instrumentation rather than how soon could you put it up.

Mr. GREEN. Thank you, Mr. Chairman.

SPACE STATION EXPERIMENTS

Mr. BOLAND. Let me ask you, in addition to generic costs, NASA has to have some provision in this budget for experiments which are going to be conducted for the Space Station. For instance, you intend to launch some payloads, but there is no provision in the 1988, 1989, 1990 and 1991 budget projections for these experiments. They are going to cost money.

You know what the experiments are going to be. You have some idea what the experiments will be, John. Don't give me a lot of words; I would like to know what the experiments will be and how much doubt do you actually attach to those experiments.

Mr. HODGE. As far as the NASA budget is concerned, it is up to Dr. Edelson to say how much those experiments will cost and when he will provide them, and Dr. Colladay, who is also providing a wedge in his budget to do the technology experiments. I am sure Dr. Edelson can tell you how he is budgeting for those right now.

Dr. EDELSON. I would be glad to.

The concept is that we would provide for the funding and develop the experiments. John's office would provide for the facilities that we would use.

Sometimes it is difficult to determine where the facility stops and where the experiments start.

Mr. BOLAND. Let me ask you, do you now know what experiments will be developed in that time frame in 1988, 1989, 1990, 1991, so we will have some idea of what the cost is going to be in that period of time?

Dr. EDELSON. Yes. We have a very good idea.

Mr. BOLAND. Can you give us that idea?

Dr. EDELSON. I can give you some examples.

The polar platform, for example, is oriented around synthetic aperture radar and imaging spectrometers. Those are two key instruments that work in the microwave and in the optical IR bands that are so large, powerful, and, as a matter of fact, expensive in themselves, that they justify the polar platforms, and the incremental cost of other smaller instruments would be worthwhile.

We already have both of those instruments under development. You saw in SIR-A, SIR-B and C and D flights which are now scheduled, the incremental development of the synthetic aperture radar. Also, we have an airborne model of the imaging spectrometer, which we were flying and doing experimental work with. Unfortunately, the airplane that it was on burned up a year ago, so we have to replace that now.

But it is an ongoing development project. Each of those instruments will be several hundred million dollars in investments by the time we——

Mr. Boland. In the projections that have been made for the 1988, 1989, 1990, and 1991 time frame, are there any specific dollars attached to these particular experiments?

Mr. Newman. Mr. Boland, on the experiments that will be flying on the Spacelab in that time period, from which many of these experiments will evolve, in fiscal year 1987, there is a little over $200 million. That amount grows by fiscal year 1991 progressively up to about $300 million.

In addition to that, there are——

Mr. Boland. This is on the Space Station, of course. You are talking about the space station.

Mr. Newman. I am talking Spacelab.

Mr. Boland. What about the station?

Mr. Newman. I am saying many of the experiments, like the radar that Dr. Edelson mentioned, will be developed through the Spacelab and evolve onto the Space Station.

Mr. Boland. But they are going to be, as I understand it, specific experiments developed for the Space Station in this time frame—1988, 1989, 1990, 1991; is that correct or not?

Mr. Newman. They won't be carried up to the Space Station until about 1994.

Dr. Fletcher. About three or four years off.

Mr. Newman. So development of those will occur in the 1991, 1992, 1993 time period.

PROJECTED COST OF EXPERIMENTS THROUGH 1993

Mr. Boland. Do you have any projections for money that we will be providing in that time frame to pay for the experiments?

Mr. Newman. We don't have specific projections, but much of that same effort that I mentioned in connection with Spacelab at dollar levels like those is projected in the figures we ran out through 1994.

Dr. Fletcher. Can I make a comment, Mr. Chairman?

I think your questions are very, very good and appropriate. I think we really need to address those outyears, the 1993, 1994, 1995 time period, and make estimates for you of what kind of experiments we are talking about and what is our estimate of the cost.

I think what I gather is we just haven't projected that far in advance. We have provided for those experiments, but we have not provided the dollar estimates because we don't normally reach that far yet.

Mr. Boland. That is fine. This is a question that we had the staff ask NASA some time ago, and we couldn't get an answer.

We will stand in recess now until 2 o'clock this afternoon.

AFTERNOON SESSION

USE OF SPACE STATION DURING ASSEMBLY SEQUENCE

Mr. **BOLAND**. The Committee will come to order.

We will get back on the Space Station for a moment. What strikes me really about this program is that you can tell me, or tell the Committee, almost to the day when you are going to have a permanently manned Station, but you have not been able to tell us really what you are going to have up there in the way of experiments, and what the costs will be.

So let me ask this question: From the time of the first element launch, which is, as I understand, January of 1993—is that correct?

Mr. **HODGE**. Yes, sir.

Mr. **BOLAND**. Through launch number 8, which I understand will occur perhaps a year later, early in 1994——

Mr. **HODGE**. Yes.

Mr. **BOLAND**. What specifically do you plan to do in a useful manner with the Space Station? Do you have any experiments going on within that year?

Mr. **HODGE**. We have not selected the specific experiments to go onboard during that period. The majority of that time will be spent assembling the Space Station. As a matter of fact, the first four flights are really the basic parts of the Space Station, the structure itself, and the first parts of the power, and the attachment points for the attached payloads.

As we assess the capability of the shuttle at that time, it will be possible that there is some spare lift capability, and during that period of time we will take up some of the attached payloads.

What we will be doing this summer and through the fall is an assessment of those experiments that will go onboard the Space Station in the very early stages to satisfy two requirements. One of them would be that they do useful science or applications or technology work, and that will be done in conjunction with Dr. Edelson. The second thing is that those experiments are used to test the capacity of the system because we have to be sure that the Space Station that is going up there is, in fact, useful for those experiments. So the first set of experiments will try to meet those two criteria.

We have several workshops going on this summer through the fall to work specifically on the definition of those experiments that can be useful in the early stages of the program.

Mr. **BOLAND**. So it is planned to do experiments on the Space Station itself during this period of time, between the second launch and the eighth, where you get the permanent crew up on the eighth launch?

Mr. **HODGE**. I think it is the ninth, but, yes.

FUNCTIONAL ALLOCATION

Mr. **BOLAND**. Ninth.

Let's talk for a moment about your concept of a functional allocation. As we have indicated, as NASA told us already, the original concept for international participation was that the contribution would be additive. We would provide a basic capability and they would provide an additive capability. Is that correct?

Mr. HODGE. We approached it that way to begin with because we didn't know how everybody was going to come out, and it didn't make sense to have a coordinated design——

Mr. BOLAND. Was that the original concept?

Mr. HODGE. Yes, it was.

Mr. BOLAND. All right.

Now, as I understand it, when you started to run into funding problems, you began to look at the functional allocation approach; is that correct?

Mr. HODGE. I don't really believe that the functional allocation approach was driven so much by——

Mr. BOLAND. Phil, you are shaking your head. Is that so?

Mr. CULBERTSON. No. I think John and I are saying about the same thing. We decided on the need for functional allocation in order to make a proper blend of capabilities and resources; that is, power, manpower, and that sort of thing, as we had defined it to you earlier. By that I mean, if we did not move towards functional allocation, it appeared very early that we were going to have three laboratories, all full of furnaces, for materials processing instruments and experimentation. The furnaces are large power systems.

If that was the case, because of the Japanese interest in materials processing, our interest in materials processing, and the European interest in materials processing, we would find a Space Station in which about two-thirds of it had to be shut down because the limitations we were having within the 75 kilowatts of power. Or it seemed two-thirds of the facility would have to be shut down at any one time. So, you use a third of the Space Station for a while and then use another third of the Space Station. It didn't seem to us that that made an effective use of total capability.

Mr. BOLAND. That was not your first concern, as I understand it. The theory of the functional allocation, as I understand, is that the Japanese would build the technology development laboratory; is that correct?

Mr. CULBERTSON. That was the result of our thinking about functional allocation. The idea of functional allocation was to try to get a total integrated capability and get the Japanese to do some of it, the Europeans to do some of it, and us to do some of it.

Mr. BOLAND. You understand why I am taking you in this direction?

Mr. CULBERTSON. Yes.

Mr. BOLAND. And the thrust of these particular questions is because that was our understanding—that the Japanese would build the technology development laboratory, the Europeans would build the life sciences laboratory, and we would build the materials processing laboratory. At least those functions would be the primary drivers in each of those laboratories. Is that correct?

Mr. CULBERTSON. That evolved after about nine months of work on the subject with all the parties involved. That was what we in the United States came down to. But it wasn't the way it started. It did not start out with any presumed allocation. It started with a recognition that without some kind of an allocation we would all go in the same direction.

REQUIREMENTS FOR LIFE SCIENCES LABORATORY

Mr. **Boland**. Let's get a look at what you intended to include in the United States' life sciences module and more or less use that as a baseline to measure the European contribution to test whether it meets the functional requirement of the life sciences module.

Is there any objection to that approach at all?

Mr. **Culbertson**. No.

Mr. **Hodge**. No.

Mr. **Culbertson**. But you will have to take into account the greater definition of "life sciences."

Mr. **Boland**. All right.

Do you want to give us an explanation of that, what the baseline was?

Mr. **Hodge**. The first baseline for a life sciences lab was as a result of a study that was done for Dr. Edelson out at Ames Research Center by the McDonnell Douglas Company. This was done about three years ago. They had a rather clear definition of what a life sciences lab would look like. Now, in parallel with that, they have been doing separate experiments on the Spacelab and producing instrumentation for the Spacelab. At the moment, we do not have a specific definition of all of the racks that would go into a life sciences lab on the Space Station. Decisions on the outfitting function will not really be due for another couple of years, I would guess.

Dr. **Edelson**. Yes.

Mr. **Hodge**. However, we have enough background information from studies done before to know the characteristics of that equipment—for example, the kind of heat rejection that we would need, the sort of power that would be required to go to those racks, the data rates, and so on.

We also have a list of the things that are required for the health maintenance facility, which we also propose to put into the ESA lab. So, we know the characteristics that are required generally for the resource allocations within those labs: power, number of people to operate it, the volume required for it, the number of racks, and so on.

We have that in the users data base and the Europeans have worked with us on that.

Now, in our discussions—let me be quite frank with you. In our discussions with our international partners, it has taken us most of a year to get them to accept the fact that we are not talking about national enclaves but that we are talking about facilities where there is equal access by everybody to every piece. That was not a well-accepted concept when we first started it.

At the moment, the Japanese, for example, still want to put some of their materials processing research—

Mr. **Boland**. Both want to do that, don't they? They want to use the laboratories for materials processing? Am I correct?

Mr. **Hodge**. Yes, absolutely. But they want to put those racks in the labs that they are going to produce. What we have done is, first of all, to baseline a standard rack.

MATERIALS PROCESSING ACTIVITIES IN VARIOUS LABS

Mr. **Boland.** What gives me a problem there is what percentage of that work time will be used for materials processing instead of technology development or whatever work will be done in the life sciences laboratory. My understanding is that functional allocations don't work unless the various modules truly are functional and distinct from each other.

What you are doing here is—they are not distinct from each other. My understanding is that whatever negotiations are going on, you are permitting the Japanese and Europeans to build these laboratories and also to do whatever materials processing they think they want or ought to do that.

Is that correct or not?

Mr. **Hodge.** No. I don't think that is quite correct. We are gradually working them around to——

Mr. **Boland.** Let me ask you this, John: What is the biggest pay-off? What laboratory gives you the biggest pay-off in space, on the Space Station?

Mr. **Hodge.** I know the conventional answer to that is that it is materials processing. But it is not clear to me that that will in the long run be the biggest pay-off.

I personally believe—my own personal feeling about that—is that the lab associated with technology development in space is going to be the biggest pay-off for this country as we begin to move to new technologies over the next 10 or 20 years, and as we need to test things in space.

You can ask Dr. Colladay about this, but I think that is the most likely pay-off in the early term.

The materials processing one is sort of betting the come. Everybody believes that that is going to be very large, but I don't think that the jury is in on that yet, and we——

PREDICTED USES OF SPACE STATION

Mr. **Boland.** I think the program is being sold on the fact that that is probably going to be the most significant aspect of the Space Station, the most significant part of it. You get the salesmanship that what can be done up there in the Space Station will probably pay for the entire space program, going back to even Apollo.

Mr. **Hodge.** No, I know Dr. Edelson will disagree with you on that one, because he thinks the most important use of the space station is the science applications.

Mr. **Boland.** Let me ask you, would it make more sense for us to build a truly usable life science module and let the Europeans contribute whatever they want to the station, and then charge them for the use?

Mr. **Hodge.** I really don't think so, because when we look at the total volumetric capacity of the three labs that will be provided, plus our habitation lab, there is enough volume there to keep us going for the first three, four, five years. I don't think we need another lab, or more volume to go up there to satisfy the user community during those first three or four years. But what I do see is that much of the equipment, the life sciences equipment, which we will actually be the prime user of anyway, will be put into racks and supplied by the science organizations, life sciences organizations in Dr. Edelson's directorate.

Mr. **Culbertson**. I think the real consideration here, Mr. Chairman, is that we had a choice. We could either supply all the laboratories that we felt were desirable and let the Europeans supply what they wanted in the way of laboratories, the Japanese what they wanted.

NEGOTIATIONS WITH THE EUROPEANS AND JAPANESE

Mr. **Boland**. But, they don't want to supply a laboratory that is just targeted to technology development or to life sciences. They want a supply laboratory where they can do materials processing. We are paying—you know, this is a very expensive program.

Mr. **Culbertson**. Yes.

Mr. **Boland**. We are paying for it. We ought to get benefits out of it; whatever can be developed in the area of materials processing, we ought to be doing it. Is that unfair to ask that?

Mr. **Culbertson**. I think we will have much greater capability in the materials processing area by being able to use all of the laboratories.

Mr. **Green**. I guess what is troubling this Subcommittee is that we see a progression where an $8 billion price tag is put on this thing. Then, you start the definition studies and to do what your people really want to do, it takes $13 billion.

Mr. **Hodge**. Excuse me, sir, but that really isn't a fair statement. As I mentioned this morning, that $13 billion had estimates in it which were not to be included in the total amount of money. Some of it was due to overlap, some of it was due to extensive subsystems which were overdesigned, and we recently took a great deal of money out of that independently of whether we were meeting the requirements for the—

Mr. **Green**. Let me go on with our perception from this side of the table, and obviously, it is your responsibility to get the pieces to see if they fit together as economically as possible.

Mr. **Hodge**. Sure.

Mr. **Green**. And I don't challenge that. But we also see a budget crunch coming up ahead, and we see a very high degree of risk, and one that seems to be aggravated by the way the negotiations are going with the Europeans and Japanese, that in the end, because of these budget pressures, we will wind up providing the vehicle which is not technologically a very sophisticated vehicle, and they will get all the technological benefits because we will run out of money to do that.

Dr. **Fletcher**. Mr. Green, can I suggest that that won't happen on my watch. We are going to do a lot of the dealings while I am still here, but we are going to have to rely on you to keep after us to be sure that doesn't happen after I leave the agency.

We can't give you a lot of the specifics because we are talking about a long period of time—eight years into the future. But what we can't allow to happen is that we provide the facility and they get the use out of it.

Mr. **Green**. I am talking about negotiations going on right now, not sometime in the future.

Dr. **Fletcher**. And we can't do that now, it won't happen unless we are very careless and sloppy.

Mr. **Boland**. That is good. That is one of the reasons we feel so deeply about this, as Mr. Green said; you look into the future and you will have a budget crunch and finally, we are hit with the tab. You say that you won't permit that to happen, and we hope we can help you in not permitting that to happen, too.

Dr. **Fletcher**. That is fair.

Mr. **Hodge**. Excuse me, one of the fundamental negotiations that will take place for the C/D phase is that the percentage utilization of the Space Station capability, whether it be the platforms, co-orbiting, polar, or on board the manned base, will be proportional to the investment. There is absolutely no doubt about that. That is very clearly on line in our negotiations and nobody has questioned us on that subject.

Mr. **Culbertson**. I think as a result of these negotiations, you will find that the Space Station is a much more capable system for our investment than it would have been if we had undertaken the whole thing. As long as we have access to it all, which we will, and if the use of it is proportional to the original investment, I think we have the opportunity to have much greater, much more effective use for ourselves than would have otherwise been the case. It also seems to me that the benefit from having a Space Station comes from what we can do in it rather than the technology which allowed us to build the laboratory.

FUTURE BUDGET CONSTRAINTS ON STATION

Mr. **Green**. I couldn't agree more. I think the Space Station itself is not technologically a very sophisticated step forward compared with what we have, but what worries me is that whatever our theoretical rights—as I say, I am not altogether happy with the reports I hear on the current negotiations—but whatever theoretical rights they give us, I am worried that as I look at our budget situation that when push comes to shove, and it is time to fund these very vaguely defined operating expenses, we don't have the money there, and thus, we have created a not very sophisticated bus which is taking along lots of other people to very sophisticated work.

Mr. **Culbertson**. It is that negotiation, how we apportion the use of it, how we apportion the costs of operations that I think is a very critical thing. I certainly agree that that has got to be handled very carefully.

Mr. **Green**. But at the end, we have to know we can fund our experiments, and it is very difficult to define with the great budget constraints.

Dr. **Fletcher**. I would like to add one other thing, Mr. Green, We are not pushing the state-of-the-art in any single degree of technology on the Space Station like we did on the shuttle. We pushed deliberately the state-of-the-art on the engine, and pushed deliberately the state-of-the-art on the thermal protection system. In the Space Station, we are not doing that, except if you want to make the case on the data processing, we are pushing the state-of-the-art. But the technology, what I call systems engineering of putting together these modules in space, that is a new thing, even the Russians are not anywhere near as far along as we plan to be by then.

Maybe they will move along and catch up, but those are pretty high-tech operations in space. And we will learn a lot from that. That doesn't change my original position with you, that we have got to watch that we get our fair share of our investment in terms of the science and the materials processing and all the life sciences that are part of the program. We do have to make sure that happens. But we do, and all of us, the Europeans and Japanese, too, want to get that experience in building things in space, which is not a trivial point.

Mr. **Green**. Thank you, Mr. Chairman.

Dr. **Colladay**. Could I add a word on advanced technology from the point of the user of the Station and the Station itself? As John pointed out on several occasions this morning, we are planning a number of experiments and defining classes of experiments of advanced technology that can be done utilizing the Station, where we need a zero gravity environment.

We are also instrumenting the Station itself, as the best specimen of control of a large structure that we will have to work with. Just as we have instrumented the shuttle as an experimental vehicle, we are looking at the Station as a way to get smart and understand the control and dynamics of a large structure.

We are very much involved in the utilization of the Station for technology development in things like control of large flexible antennas that need to be experimented with in the Station to develop the design codes for designing systems like that; in fluid transfer where we don't really have a very good understanding on handling and storage and transfer of cryogenic fuels; power and thermal management, all the kinds of things that, if you want to work and operate routinely in space, we need to write the design book. We need to use this Station both from its utility standpoint and the Station itself in its assembly.

So, from a technology standpoint, we are looking at this as a laboratory in space, and defining right now in our advanced technology program the things that we need to do and the requirements that we are putting on Mr. Hodge to build into the Station as a facility. We built a wind tunnel, without having defined precisely what we were going to put into the wind tunnel 15 years in advance. We do define it, and build into it the capability necessary to pursue the technology that we develop.

SPACE STATION WORK PACKAGES

Mr. **Boland**. We certainly appreciate that description of it. I don't think anybody on this side of the table would disagree with that, either. Let me ask you about the work packages. You will have four packages. The first package is a common module managed by the Marshall Space Flight Center. The second work package involves the infrastructure, the truss, command and control, and is managed by the Johnson Space Center. The third package includes the unmanned platforms, polar orbiting and co-orbiting, and the payload servicing function. That is managed by Goddard.

And the fourth work package, which includes the power requirements, is managed by the Lewis Research Center.

Now, am I correct in understanding that these work packages have serious overlaps that need to be reworked? I do know that the staff has advised us that the work package two contractors believe that there can be substantial savings gained if the packages are reworked.

We have heard quotes of savings anywhere from $200 million to $1 billion involving reworking the work packages.

Do you have any idea whether this is correct or is there any estimate of the savings that can be derived from reworking these packages?

Dr. FLETCHER. Mr. Chairman, I would like to, of course, have Mr. Hodge and Mr. Newman to answer the details, but those work packages probably do have some overlap and probably should be shaped some before the RFPs are finally issued. On the other hand, there are also pieces of those work packages that are, from my point of view, coming in new. I think we have got to have a better integration of these and what constitutes that work package, may be just civil servants or it may be that we will have to get an integration contractor.

We have not really decided, as we have expressed before, on the way we are going to manage this thing in depth. But there is a systems integration piece that has to be added to these work packages to make it all play together, so to speak. I am not sure how these squeezes that you are talking about and increases that I am talking about balance out at this point. I hope by the end of the year we will have that.

Mr. BOLAND. You are getting a look at the work packages yourself, as I understand it.

Dr. FLETCHER. Since we last met I have had a briefing on this.

Mr. BOLAND. And when might you come to some decision on whether they ought to be reworked and whether that is going to affect whatever schedule you have planned?

Dr. FLETCHER. I think Mr. Hodge will have to answer that, but I think that we are going to start looking at those work packages in some depth this week. As I mentioned, probably not fully, General Sam Phillips is going to take a look at the entire NASA program to see how we manage our programs, but as a subset of that, he is going to take a very hard early look at how we manage this Space Station and the definition of the work package is part of that look that he is involved in. Now, he has a crew of people that he is pulling together and they have already started to work. Having said that, John will have to give you the details.

Mr. HODGE. We are aiming towards a decision on whether or not to change the work packages and how to handle the systems engineering and integration function by the first of July. That is the schedule we are working on right now. It was possible to do some modification to the work packages this week.

We had all of the Level C project managers, that is, from the four centers, and the system engineering group at Johnson, together working out how to get rid of these overlaps. I issued a program directive this week to get rid of the overlaps between the packages.

Now, remember, those overlaps were put in there deliberately. It was a part of the original concept to try to get different ideas from different contractors so we deliberately put the overlaps in. That resulted in some of the confusion in costing because very often things were costed twice and we had to take those out before we started to assess the overall program costs. We have taken those overlaps out.

Mr. BOLAND. You have already taken them out?

Mr. HODGE. Yes, sir. The overlaps.

Mr. BOLAND. Then if you have taken them, you won't get a savings between $200 million and a billion dollars, will you?

Mr. HODGE. The arguments now going on are the nature of the test and evaluation period prior to launch and whether there is a more or less expensive way to do that. And the center of that really is where the responsibility for the integration function and how big that integration function is. We have some differences of opinion within the agency as to the most efficient way to do that. That is really the last significant problem that has to be solved as to whether we do the system integration with a single contractor or whether NASA does it, spread out amongst the several contracts. There is a valid and rational set of arguments that we have to go through to choose the best approach for that.

REQUESTS FOR PROPOSALS

Mr. BOLAND. When are you currently scheduled to release the RFPs for development?

Mr. HODGE. First of October. Let me modify that somewhat. We are aiming at the first of October. That is on the assumption we will have an appropriation.

Mr. BOLAND. Would it be fair to say that it would be difficult to release those RFPs until you have agreements in principle on the memoranda of understanding with the Europeans, Canadians, and Japanese—and you have some input from this Committee?

Mr. HODGE. I think that what we are calling program agreements, that have presently been taking place between Christmas and now, and which I expect to happen also between ESA, are really sufficient for us to move into the RFP period. What will happen if, in fact, we do not get total agreement on the build phase which we do not expect to have until January of next year, and one or other of the partners modifies their position or drops out, is that it will still allow us to make modifications, during the negotiation period of the contracts, which really doesn't take place until April of next year. The negotiations which will take place during the month of April will allow us to modify the U.S. part of the program, if, in fact, we have not reached full agreement on the total complement of hardware development that will be done by our international partners. We have left a period of about four or five months in there between the time when we expect to get the agreements from them and the time when we have to negotiate our contracts.

ANNUAL OPERATIONS COST OF SPACE STATION

Mr. **Boland**. What is the current estimate of the annual operating cost of the Space Station?

Mr. **Hodge**. Phil may want to add to this because we did an assessment of this last fall. Our assessment, based on the definition of operations that we have in the report that we gave you last year, is about $1 to $1.5 billion a year, assuming that we cannot get any more efficiency in the operational process. I personally believe that we can do that. We have put together an operations management concept which will bring the whole of the operations organizations under a single mantle. We are planning to put a group together this summer to put an implementation plan together.

It is my belief that for the Space Station side of that—because this is really in two pieces—there are the pieces that are associated with launch, and we will not be able to control the operations cost of the shuttle directly. But on the operations cost of the Space Station itself, my belief is that we can improve the efficiency of operations by as much as a factor of two. So I think we can take maybe half a billion dollars a year out of the current estimate. Phil, you might like to comment on that.

Mr. **Culbertson**. I think it is wise right now until we can prove to ourselves that that is possible, to proceed with the assumption we won't do it.

Mr. **Hodge**. Yes.

Mr. **Culbertson**. It is very difficult to make that conclusion, but I would not want to deceive myself and you.

Mr. **Boland**. So you are able to take out between a billion and $500 million a year; is that correct?

Mr. **Culbertson**. Yes.

Mr. **Hodge**. Yes.

Mr. **Boland**. You can do this for the record, unless you have the answers now. Can you break out the components of the $8 billion total at the sub-system level? If you can't do it there, can you break out the components at the system level—you know, the power and materials processing lab and that sort of thing. Would you do that for the record?

Mr. **Hodge**. I can do that. We have that down to a pretty good level of detail. I don't have it in my head, unfortunately.

[The information follows:]

A breakdown of the estimated $8 billion total at the subsystem or component level is as follows:

[In billions of dollars]

Subsystem or component	*FY 1984*
Structures	0.4
Power	0.7
Attitude control	0.3
Communication and tracking	0.4
Thermal	0.1
Data management systems	0.4
Modules	1.2
Habitation	0.6
Servicing and extravehicular activities	0.6
Platforms	0.3
Program support, systems engineering, and integration	2.4
Definition program	0.6
Total	8.0

Mr. **Boland**. What is the total cost of facilities in terms of new construction of new facilities for the Space Station?

And is that particular cost outside the $8 billion or is it included?

Mr. **Hodge**. First, it is outside the $8 billion.

Second, our estimate at the moment is around $330 million for all facilities in 1984 dollars.

AUTOMATION AND ROBOTICS

Mr. **Boland**. Let's get into another area that concerns the state-of-the-art. We will review the bidding for just a minute on robotics and automation. I think most of the people on that side of the table understand—we certainly do on this side—that the Congress supported an automation and robotics effort in connection with the Space Station.

Last year we added $5 million to Space Station to enhance that effort. In the report language—which by the way was worked out with NASA—indicated that there would be a telerobotic servicer function that would be used to assemble the Space Station, and that the orbital maneuvering vehicle, the OMV, would have a so-called "smart front-end" that would help to drive the state-of-the-art in automation and robotics. That is what the conference report language clearly said.

Then NASA came back to us and indicated that the Canadians were not happy with that language So, NASA suggested to the staff that the Canadians would build a telerobotic servicer with what was termed a "robust dextrous manipulator" that would be used to assemble the Station and move large payloads around on the Station. We would develop the very sophisticated dextrous manipulator that would be used to service the payloads on Station. Now we understand that the Canadians want to also build a dextrous manipulator that would service all the attached payloads in their attached position, which, as we understand it, would represent probably 90 percent of the servicing of attached payloads while we would use our dextrous manipulator to service visiting satellites. Is that correct?

Mr. **Culbertson**. Is it correct that there has been a voice in Canada——

Mr. **Boland**. Do you disagree with this scenario so far that I have just described, Phil.

Mr. **Culbertson**. It is my understanding that some in Canadian industry would like to do that, yes.

Mr. **Boland**. There is no doubt about that. Yes.

Mr. **Culbertson**. All right.

Mr. **Hodge**. I think we can show that.

Mr. **Culbertson**. So if you will say it is your understanding that Canadian industry would like to do it, then I certainly would agree with you.

Mr. **Boland**. It seems to me that we are getting the short end of the stick in this area. I want to make it clear that NASA is going to proceed in this budget with enough dollars to develop a dextrous manipulator for the Space Station that will service all payloads—no matter whether they are visiting or attached. Is there any doubt about the position that this Committee will take in this area?

Mr. HODGE. No.

Mr. BOLAND. Do you disagree with that?

Mr. HODGE. I understand the position you are taking. I would think under some circumstances that may not be the best position to assume once we know what we have on the Space Station.

U.S. DEXTROUS MANIPULATOR

Mr. BOLAND. Let's proceed further then.

How much is needed to have that dextrous manipulator ready when the Canadian robotic arm is launched on either the first or second shuttle flight for the Station?

Mr. HODGE. We have put a program together which, unwrapped, is estimated at $105 million. That program plan is presently being prepared. For the purposes of launch and assembly, that manipulator, the smart manipulator, is really not required on the second flight. We really don't see the need for a smart system of that kind to be available until we actually start to service payloads which visit the station like, for example, the telescope.

Mr. BOLAND. We have the feeling on this side of the table, John, that there is a requirement for our dextrous manipulator in the early stages and not later on in the assembly sequence. What we have discussed on this side of the table, and what we would like to see happen, is some attached payloads put up as soon as possible. The contractors have told us that that is possible as early as the second flight, and we want to be sure that our dextrous manipulator, the United States dextrous manipulator, is funded and built and ready to service whatever is up there.

Mr. HODGE. Oh, I would agree with that, yes.

Mr. BOLAND. Are you agreeing with that with respect to the time, too?

Mr. HODGE. You said whenever something is up there that needs to be serviced. It is our perception at the moment that there is no requirement for such a manipulator early on in the assembly phase.

Mr. BOLAND. Will the Canadians have that manipulator built at that time? They would be doing the assembly.

Mr. HODGE. They would have the large-scale arm for assembly, but there is really no requirement for what we have termed robotics.

Mr. GREEN. This, again, is getting back to your assumption that you won't do anything of significance with the Station until you have it permanently manned.

Mr. HODGE. No, I don't think so, sir. We have looked at the early attached payloads. We are planning to put five attachment points on the early Station. Two of those attachment points will have cross-pointing capability as well; each attachment point has the possibility of putting five payloads on.

Now, we have the time-phased attached payload information from science and applications and in general the characteristics of those instruments are that they do not require detailed servicing.

You actually have to take the whole thing off and bring it back. Maybe you can give them an example. One of them, I know, Dr. David Black, our chief scientist, is working on. It is the astrophysics metrical robot.

Dr. **Fletcher**. Mr. Chairman——

Mr. **Hodge**. These in general don't require the very high level of detailed manipulation.

Dr. **Fletcher**. Can we leave it this way: that the first time the detailed dextrous manipulation is needed that we will provide that system? We are now arguing about how we are going to evolve the Space Station and I think if we leave it with the ground rules that we will provide the dextrous manipulator as soon as it is needed—that doesn't mean the Canadians won't stick one on their piece of the Space Station that doesn't do anything before that, but that is their problem.

Mr. **Hodge**. That is good.

FISCAL YEAR 1986 CONGRESSIONAL DIRECTION

Mr. **Boland**. Let me just read the critical phrase in the conference report. "The conferees have included a total of $205,000,000 for space station activities including $5,000,000 which is available only for automation and robotic activities. Specifically, the Committee on Conference directs that the $5,000,000 be used for delivery of a flight telerobotic system at the time of initial space station operational capability for a mobile remote manipulator for station assembly and maintenance and a smart front end on the orbital maneuvering vehicle for remote operations and servicing."

The critical phrase in the conference report clearly indicated that the mobile remote manipulator system is for station assembly and maintenance. All of this was agreed to by NASA when they sat down with this Committee and actually drafted the conference report.

Mr. **Culbertson**. There was an assumption at that time, and we made it and I think we, in discussing it with you, talked about it, that there would be a single remote manipulator on the Space Station. In that—that was a year or two years ago, whichever doesn't matter.

Mr. **Boland**. Last November.

Mr. **Culbertson**. The concept has modified somewhat, but the principal, as Mr. Beggs said, is if we don't need a smart front end on that assembly, then it makes it very difficult to comply with both aspects of that direction which says have a mobile remote manipulator for IOC and have one during assembly. If we don't need it during assembly, then it makes it difficult to comply.

Now, in fact, by the time we use a mobile remote manipulator, we will have to have a Station with the man aboard to use it from, and that implies that we will have one of the pressurized modules there unless we operate it from the space shuttle.

We would be more likely to use the shuttle manipulator in that kind of operation if the shuttle were there.

Mr. **Green**. Does the shuttle manipulator have that robotic capability?

Mr. **Culbertson**. I don't know what that kind of robotic capability means at the moment because we don't know what that first experiment will be that requires it, but I am trying to visualize how we comply with all this intricate set of requirements when many of the requirements are set up fairly early in the evolutionary understanding of this.

Mr. **Green**. I guess to try to cut through it, what we are concerned with is, as we see the progress of the negotiations with the Canadians, we seem to be getting sliced away in terms of what the understanding was that this Committee and you had as recently as last November when that language was written. We can foresee, given the kind of budget climate we are going to be in throughout this period, that the day will come when there will be a Canadian arm there which will have both the robust capability and the dextrous capability and we will be scrounging for things to cut out in order to meet budget requirements and we are going to wind up with very little sophistication out of this thing.

Mr. **Hodge**. Clearly, the U.S. manipulator will be used for all of the satellites which come to the Space Station for service and repair.

That is by far the most sophisticated thing that we can think of that needs to be done, and those are all designed out of our science and applications program.

ROLE FOR U.S. SERVICER

Mr. **Boland**. Do I understand what we are going to do is just service the satellites that come to the Station and that the Canadians' effort is to service the packages that are attached to the Station?

Mr. **Hodge**. It is very difficult for me to split it up that uniquely.

Mr. **Boland**. That appears to me to be the way it is split up now. Have we reached an agreement yet?

Mr. **Hodge**. We have said they would have the large-scale capability and we would have the fine-scale capability. I have tried not to use the pejorative terms, but talk in terms of robust and expert because that just doesn't help in negotiations. In fact, I see the predominant use of the U.S. capability in servicing free-flying platforms which are the most sophisticated instruments that we have to service.

Dr. **Edelson**. And highest priority. Maybe I can help here a little bit. I believe priorities are concerned—we have laid on John's organization a set of priorities; top priority is to be able to service and repair the spacecraft that will be in orbit at the time that the Space Station goes into operation at IOC. That is first the Hubble Space Telescope, the Gamma Ray Observatory, Solar Max Mission and other approved programs that will be in orbit at that time.

SERVICING OF ATTACHED PAYLOADS

Mr. **Boland**. Let me ask you, Burt, have you reached an agreement with the Canadians that they are going to service all the attached payloads? I want a specific answer here. Have you reached that agreement with the Canadians, or have you negotiated that point with the Canadians, and are we now in a position where the

Canadians are going to service all attached payloads and we are going to service only visiting satellites?

Mr. HODGE. I hate to use the word only. The word we have used is predominantly. We have done that in order to leave ourselves a hedge as to specifically what we will be doing at a given time.

Remember——

Mr. BOLAND. Am I correct in believing that the servicing of the attached payloads is a much more sophisticated job than servicing the visiting satellites because you have——

Mr. HODGE. No, sir.

Mr. BOLAND [continuing]. Because you have a smart end on the manipulator?

Mr. HODGE. No.

Dr. EDELSON. Just the opposite.

Mr. BOLAND. That is not the way we understand it.

Dr. EDELSON. In terms of our science requirements, we have very high priority, very sophisticated and very demanding requirements for servicing the spacecraft which I mentioned and AXAF and SIRTF which we hope to get improved over the years.

We have no requirements at IOC for attached payloads.

Mr. GREEN. You really startle me because you are telling me the most sophisticated things are the free-flyers which are essentially man-tended.

Dr. EDELSON. Servicing of the free-flyers, yes.

Mr. HODGE. No——

Mr. GREEN. Well, what's right? You are telling me yes and you are telling me no.

Mr. HODGE. The most sophisticated robotics is with servicing visiting spacecraft.

Mr. GREEN. That is the most sophisticated piece of work.

Mr. HODGE. There are a lot more very sophisticated things we have to do on the Space Station which have nothing to do with servicing spacecraft.

Dr. FLETCHER. But the most sophisticated servicing that has to be done is for the visiting craft.

Mr. CULBERTSON. Yes.

Mr. HODGE. Yes.

Mr. BOLAND. Are we going to service any of the attached payloads which I think are probably very significant, too? I would think you would think so.

Mr. HODGE. The list of instruments we have right now from Burt generally are serviced by replacing them, not by changing the instruments—there are no focal plane instruments on the attached payloads that we have identified at the moment. By and large, we would use the Canadian arm to pick them up and take them somewhere else. There is virtually no in situ servicing that has to take place.

Mr. GREEN. What will the Canadians do with their dextrous manipulator?

Mr. HODGE. Can I answer that question in a slightly different way because there is an assumption that all of the things which are on the Space Station belong to the people who provided them. What we are going to have there is an international crew, the vast majority of which will be U.S. and that crew will use whatever capability exists whether it comes from Japan or Canada or Europe or the U.S.

The use of those facilities will be according to whatever it is we want to do at a given time.

ROLE OF CANADIANS' DEXTROUS MANIPULATOR

Mr. GREEN. I still don't understand what it is the Canadians' dextrous manipulator will do if, in fact, you tell me that none of the attachments you can see for the foreseeable future are going to require that kind of skill.

Mr. CULBERTSON. Let me suggest something. We are probably getting into a very great detail on a fine subject, but I am quite willing to do that. Let me tell you the situation we found ourselves in.

The Space Station has a lot of deployment acreage. It is a big system and we expect to have attached payloads on the very top of it looking outward and at the bottom looking downward, and scattered all around us. In order to do anything with those attached payloads which are scattered all over the area, we had to have a manipulator that would be mobile. We also had to have a manipulator that was mobile in order to assist us in constructing and erecting the basic Space Station.

The need for the one which assists in constructing the basic Space Station are rather large movements and large motions and not finely dextrous. They are not putting in and taking out small screws. They are moving big structures and assisting astronauts in the assembly of the thing.

The need for working on payloads which are brought to the Space Station could very well have required more detail than that. They require the removal of screws and that sort of thing. So we were faced with the necessity of trying to accommodate Canadian participation in the program, and in order to accommodate the desire for us to build an extremely dextrous capability, we were faced with either providing two mobile remote manipulators, one the Canadians would supply which would do rather gross functions and one which we would supply to do very fine functions, or else provide the fine capability in the United States manipulator which generally would work within a confined area to which payloads or spacecraft were brought and have the mobile one provided by the Canadians with the ability to move these large things around.

Now if it is necessary to bring an attached payload to the Station structure for attention, we would use the Canadian arm to pick that payload up and move it into this small structure. That is why it is difficult to say that the Canadian arm must work on all attached payloads or not because they are two different kinds of capabilities.

But we have been very careful as we worked this to assure that the technology which goes into the high dexterity capability is the one which the United States will undertake. I know that is a slightly different look than what you have been given, but it is very difficult looking at the overall configuration and functions that must be provided for attached and detached payloads, to be quite as precise as you are suggesting you would like to be in defining exactly and in partitioning this as precisely as you would like to have it until we are closer to understanding exactly how this servicing will be done. The United States has very limited experience in servicing.

AGREEMENT WITH THE CANADIANS

Mr. Boland. Do I understand you have already signed an agreement with the Canadians?

Mr. Hodge. We have signed a program agreement for the second half of the definition phase which started the first of April.

Mr. Boland. Were you taken by surprise when the Canadians came in a couple weeks after signing the agreement and indicated that that presentation included a highly sophisticated dextrous manipulator as part of their total package? That was a surprise to NASA, was it not?

Mr. Hodge. No, sir.

Mr. Culbertson. No.

Mr. Boland. Well, you disagree with that then?

Mr. Hodge. It was not a surprise.

Mr. Boland. Was it a surprise to anyone else in the Space Station function?

Mr. Hodge. Not that I know of.

Mr. Boland. Your staff briefed the Committee staff and suggested the following points: For all attached payloads that the United States could envision for the Station as of today, the U.S. could see no need for the Canadian dextrous manipulator. The cost of developing the total Canadian package, the so-called mobile servicing platform, was substantial and the Canadians would not be able to have sufficient funds to develop a highly sophisticated dextrous manipulator. Canada needed to include the dextrous manipulator in order to sell the whole package to its Cabinet. And finally, the Canadians may have to build their own attached payloads just to use their so-called dextrous manipulator.

Those were the points made to the staff in an effort to assuage our concern that we were giving away an important function on the Station. Now, I am wondering whether or not there is any doubt in anyone's mind that it was a surprise to NASA when the Canadians came back and included in their total package a dextrous manipulator? Was it a surprise to you?

Mr. Hodge. No, sir.

Mr. Boland. Was it a surprise to anybody in NASA? No one?

Dr. Fletcher. It wasn't a surprise to me but in all fairness, Mr. Chairman, I wasn't here when that was going on. I am a little surprised at this point, though.

CAPABILITY OF THE CANADIAN DEXTROUS MANIPULATOR

Mr. Boland. There is no doubt about the fact that this particular function or activity is really pushing the state-of-the-art in robotics; is that a fair statement? And what you will accomplish with it? No doubt about it.

Mr. Hodge. Yes.

Mr. **Boland**. And is the Canadian dextrous manipulator going to have approximately the same capability as the dextrous manipulator that we envision for the U.S.?

Mr. **Hodge**. We have not put specifications together but I am sure that their desire to build something of this kind will be no different than our desire and they will push it as far along the state-of-the-art as they can afford to do so just as we would.

Dr. **Fletcher**. Mr. Chairman, that comes back to my original point, they are going to do what they want to do. We cannot control what they do to any reasonable extent.

Mr. **Boland**. We can control whether or not——

Dr. **Fletcher**. However, we can control what they do to the Space Station. In other words, they can put the dextrous manipulator on but——

Mr. **Boland**. But where will they put the dextrous manipulator if they don't have the Space Station?

Mr. **Hodge**. They will have to put it on some part of the Space Station but if there is nothing to dextrously manipulate——

Mr. **Boland**. You can see what we are driving at.

Mr. **Hodge**. It is useless.

Mr. **Boland**. We are paying billions for this Station and for some of the highly sophisticated activity that will be going on there, and we are giving part of it away. Not giving it away, but actually we are giving up what the Congress indicated in the conference report of last year we should hold.

Dr. **Fletcher**. Can I finish the statement though, when the time comes for a dextrous manipulator, I think we ought to agree that we will build that particular dextrous manipulator whether the Canadians have one or not, if we can agree with them that is the way we ought to go.

Now, what are they going to do with their dextrous manipulator before that, that is a good question. Maybe they will have to put some of their own satellites up to dextrously manipulate or something.

Mr. **Boland**. What I am doing is trying to impress NASA with the fact that NASA agreed that the extra $5 million which was added for this function last year would be used for a specific purpose—to drive the state-of-the-art in automation and robotics. Since then, through negotiations, we see that position eroding.

Dr. **Fletcher**. Let me just say this, again, as Administrator, that $5 million is going to be wisely spent. We think it is an awfully important program. Robotics to NASA is the wave of the future, so to speak. So we are going to put that to use as soon as it is needed or before if necessary. And that much we can guarantee.

Now, it is used on the Space Station, maybe we ought to come back to you and give you a better insight as to what we do vis-à-vis what the Canadians do.

Mr. **Boland**. Let's talk for a moment about the "smart front end" for the orbital maneuvering vehicle. The agreement that this Committee had with you was that the smart front end, which was also intended to be a highly sophisticated telerobotic device, would be available at the time of initial operations on Space Station.

Now we are hearing that you are not including funds to have the smart front end on an OMV by that time. Is that true?

Mr. **Hodge**. That is true. What we have, the $105 million estimate that we gave you, is for the development of a dextrous manipulator, which in its first instance will be used to operate on visiting spacecraft. Its second use would be as a smart front end to the OMV. That would require a second manipulator. We need to add to that, and in order to do that properly we need to add the telepresence capability which is the communication link and human engineering interface to do the manipulating and modifications and maintenance work on a remote satellite, remote from the space station that is, and that piece was not included in the $105 million.

We believe that the technology of the robotics telepresence capability itself is identical in fact to the robotics that we would use to service visiting spacecraft.

SMART FRONT END FOR OMV

Mr. **Boland**. Let me ask you now, what does it take in this budget—or Tom, you can answer it—to assure that an SFE, smart front end, will be developed by the initial operating capability?

Mr. **Newman**. Do you have a number?

Mr. **Hodge**. Excuse me, sir.

Mr. **Boland**. How much money would it take in this budget to assure that a smart front end would be developed by the initial operating capability?

Mr. **Hodge**. We have $10 million in this budget to begin the development program plus the $5 million that you have already appropriated for that.

Mr. **Boland**. The question is how much would you need in this budget to be sure that that is available at the time of the IOC?

Mr. **Hodge**. I don't think we need more money in this budget. We would have to ramp up at a considerably higher rate later on in the next two years or so. But for the first two years the $15 million that we have is adequate.

CIVILIAN SPACE STATION

Mr. **Boland**. I understand this Space Station is a civilian Space Station, is it not?

Mr. **Hodge**. Yes, sir.

Mr. **Boland**. The DOD has said it has no requirements at all for using the Space Station. Also, our foreign partners in the Station are totally against the DOD having anything to do with the Space Station, whether or not the Space Station will be used at all by the DOD and whether or not there will be any particular research done for DOD.

Mr. **Hodge**. In our negotiations with our international partners, the question of the DOD use of the Space Station has been the subject of concern from the beginning. When we made our visits to potential partners and made the offer with regard to the Space Station, Mr. Beggs made it clear this was a civil Space Station based on civil requirements and that it would never be used for operational military use. However, he also made it clear that the U.S. Space Act says that NASA is required to share technology and to assist the Department of Defense whenever it is appropriate to do so.

So we made it clear there was a potential for the DOD to use the Space Station for R&D work. We have had no particular problems with regard to that.

It is the use of the Space Station militarily which is the big concern on the part of our international partners.

Mr. Boland. You think the DOD might well use the Space Station, not militarily but for some experiments?

Mr. Hodge. We still have no official requirements from the DOD. They study it every year. I see a potential for research and development to be performed, particularly in the technology area and I wouldn't be surprised if eventually they have such specific requirements.

Mr. Boland. For the record, will you identify at least two potential attached payloads that could be launched on the second or third assembly sequence flight and that could be models for using a dextrous manipulator to service those payloads.

[The statement of follows:]

After a very preliminary examination by the Office of Space Station, of the few candidate payloads which appeared feasible for inclusion in the first two Space Station assembly launches and an accommodation on the Station this early in its assembly sequence, very few required any servicing and only one required servicing of a type which might demand a dexterous manipulator. This sole candidate is a materials sample exposure test sponsored by NASA's Office of Aeronautics and Space Technology. It has a servicing requirement for periodic removal of materials samples so that they can be returned to Earth for analysis. The removed samples would be replaced with new samples.

SCIENTIFIC USES OF THE SPACE STATION

Mr. Green. Before we leave the Station, Mr. Chairman, the March 1986 report by the SEAC Task Force on Scientific Uses of the Space Station suggested an upgrade of the shuttle to enable it to spend a longer time in orbit and if this is possible and the Station allows for the docking of two shuttles at a time, many extended duration experiments could possibly be done within the Spacelab of the shuttle.

Has that concept that they had suggested been explored within the Phase B deliberations on the Space Station?

Mr. Hodge. We explored that concept before the Phase B study started. The problem that we found with it was, number one, the cost to modify the shuttle for extra duration is rather extensive and the shuttle people had a lot of other things they wanted to do with any spare money. So in a priority sense, there was a question of which way you use the money.

Number two, in adding the extended capability to the orbiter, you were taking away capability to take things up in the orbiter. In other words, you had to reduce the payload capability.

We have never looked at the possibility of attaching two shuttles at the same time because there simply was never a big enough fleet even with four to use what is fundamentally a transportation system in a Space Station mode of operation.

It just was not a good use of the transportation capability. Phil was there when we did this. You might want to add something to that, Phil.

Mr. Culbertson. We examined that question in a lot of detail, Mr. Green. We discussed or I discussed some of those studies with you and with the staff up here. John is right: anything you do to extend the duration of the orbiter takes away payload capability. The other thing was that one of the principal things that the Task Force was looking at when it made the recommendation was the possibility of extending the duration so that during missions prior to the activation or operation of the Space Station we could get more experience in Spacelab kind of experiments so that we would learn operational techniques and that sort of thing better.

That is still, I think, a very valid observation to make. If there were money to spend, we could take an orbiter out of commission for normal delivery services so we could make those modifications, and a few other considerations. Then probably that would add to the initial utilization of the Space Station.

On the other hand, it is going to take some time to begin to understand how to use the Space Station no matter what previous experience we have had. We will not find that the first day we are on orbit even though we have the capability of supporting experiments that it is a highly effective thing.

There are many challenging new techniques to be mastered as we put the Space Station into orbit and for the first time dock a lot of hardware together and try to make it flow together.

I think that we will find that we grow into the use of the thing over a period of a year and a half or two years at the very best under any circumstance and that the things that we could have benefitted from earlier with an extended duration orbiter and longer Spacelab missions probably will be information that we will gain very early in the program anyway.

Having said that, I think if there were money and an orbiter to modify, it would be a great thing for us to have but I think it is a matter of looking at priorities.

REPLACEMENT ORBITER

Mr. GREEN. What is the possibility you may need that extra duration in the orbiter to assemble the Station?

Mr. CULBERTSON. Right now, it looks as though we have enough time to do the things that we want to do, but this is early in our study of how you assemble the Space Station to make that as an absolute statement and I would like—I think the agency ought to reserve final opinion on that until we know a little more about how we are going to assemble this machine.

Mr. GREEN. We are contemplating a replacement orbiter. Isn't that something that most economically ought to be decided before we proceed with that orbiter?

Dr. FLETCHER. Mr. Green, I suspect probably not. I think you need the four orbiters just for transportation. On the other hand, I think when we start considering the fifth orbiter, which I have always advocated, I don't think I am going to advocate it this year or until the deficit gets reduced a little bit, but that is a proper thing to consider for either of two situations.

One, if there is a proper number of orbiters, that we have a reasonable fleet, which I consider to be five, or if for some reason defense and commercial satellites are pulled off the shuttle, that is the time to be considering using that back-up capability for something else.

But until we have that spare capacity, I just don't think we can really modify anything or add anything to extend its duration. We just need those things for transportation system.

Mr. **Culbertson**. We probably have the time to make those studies.

Dr. **Fletcher**. We probably ought to be making those studies. I agree with that. Phil is making a facetious remark. I don't know when the fifth orbiter is going to arrive, but nevertheless, I don't see anything wrong with making the study in the event that it does arrive.

Mr. **Culbertson**. But it would be very difficult to do a substantive study on that issue right now with respect to assembly until we know more about it.

Mr. **Green**. I guess my problem is that even with the supply of structural spare parts that we have, we are talking three years for assembling a replacement orbiter, so if you are talking about suddenly deciding that in 1991 you need an extended duration orbiter, you don't have a lot of time to reach that conclusion.

Mr. **Culbertson**. We have looked into the time for modification and it is not a matter of years. You have to take an orbiter out of the fleet for a while, but the modification is primarily the addition of power and certain other things that can be add-ons.

Mr. **Green**. Given the back-up we have, you are not going to be able to take one out of service; are you?

Dr. **Fletcher**. Not unless something happens with all our other payloads besides science payloads. I suppose if DOD and commercial people decide not to pay, then we do have a spare capacity. That is the time we should be considering doing something with that fourth orbiter.

SPACE STATION DESIGN

Mr. **Green**. Let me ask one final question on the Station. When your predecessor was here, I asked him what had gone wrong on the shuttle compared with the Apollo program, and his answer—and I am expressing a longer and more thoughtful answer than my compressed version of it—was we simply hadn't allowed enough time, and enough money for all the things that can go wrong in a very complicated program.

I guess my question is with all the lessons we have learned very painfully from the shuttle what have we done to ensure that we are not going to relive those bad times with the Station?

Dr. **Fletcher**. I hope we have learned something from the shuttle. There is no sense in doing an experimental vehicle of that sort if we haven't learned something. I can just say from first-hand experience we are spending a lot more time designing the Space Station than we did on the space shuttle.

That isn't to say we didn't spend a lot of time on the shuttle. We spent a year and a half, something like that, coming up with the shuttle design. On the other hand, we did make mistakes, as always.

It is an experimental program, and we make mistakes. The other thing, though, is that we deliberately put advanced technology into the shuttle program, because we wanted to push the state-of-the-art and engine technology, which we did, and successfully so far.

And we wanted to push the state-of-the-art on the thermal protection systems which we also did, and I think we are still pushing the state-of-the-art there. We haven't decided to do that on the Space Station, as I understand it, having been briefed once on it anyway, so we have a little bit more safety for those two reasons.

One is we haven't pushed the technology quite as hard as we did on the space shuttle, and the second is we have spent a lot more time deciding what the Space Station ought to be doing than we did on the shuttle. Those two ought to alleviate the problem, but I am sure there will be some mistakes made even on the Space Station.

Mr. **Culbertson**. On the other hand, although we aren't planning to push technology significantly in those areas where we do need new technology, we have put a significant portion of the definition budget into the technology effort, about the same amount that we have put into the contract or definition studies.

So we have, I think, been very careful in trying to identify all of those technology areas that could be a significant problem to us. We have probably missed some problems, undoubtedly we have, and we will encounter some problems. We will try to allow time in the schedule to lick those problems.

Mr. **Green**. How much time and money do you feel you have in the schedule for those unexpected occurrences?

Mr. **Culbertson**. Much less in the schedule than we had before, I will admit, because we have been pressed in the schedule right now. I don't know the exact answer. John?

Dr. **Fletcher**. I can't resist a comment here. In talking to Harold Brown, former Secretary of Defense, about other problems, he says always take the engineer's estimates and multiply them by 1.5, whether it is time or money. I am not sure that is a good principle, because I think we have done a lot more.

By the way, on the R&D cost, on the shuttle, it was not anything like 1.5. The time, however, was 1.5. I don't think you can make a categorical statement of that point. I think in the Space Station we have a good chance of coming close to the schedule. I don't want to say close to the cost until the end of the year when we have really defined the cost a little better, but we will be close, close to the cost we will have defined by the end of this calendar year.

Mr. **Green**. Thank you, Mr. Chairman.

FUNDING FOR ORBITER AND STATION

Mr. **Boland**. Thank you very much.

Let me try to summarize what I think is the situation on funding for the Space Station and the shuttle. The need for a fourth Orbiter, I think we can agree, must in part be based on the payload requirements. There are two significant external factors that drive that particular issue.

The first is whether or not the Air Force will actually open and use Vandenberg Western Test Range for shuttle flights in full orbit, and the second is to what extent this and other Administrations will permit the shuttle to be used for commercial satellites.

It would seem to me that if the Air Force does not mothball Vandenberg and if NASA is permitted to seek some modest level of commercial satellite business, there is no question that a fourth orbiter is needed.

On the other hand, if Vandenberg is mothballed and NASA is restricted to shuttle unique payloads and the Space Station, the argument for a fourth orbiter is, I think, seriously weakened.

But the problem, as I see it, is that if we do not commit to a fourth orbiter, and we proceed on the current schedule to develop the Space Station, and then let's say hypothetically we either temporarily or permanently lose another orbiter in 1990, then I believe we are in serious trouble—because now what we have is a budget profile that is building a Space Station at a rate to be launched in 1993 and we have only a two orbiter fleet remaining, which I think would make it virtually impossible to launch and maintain and operate a Space Station.

I think everybody agrees with this. But we would have all of these enormous sums of money invested in a Station, and we wouldn't be able to use it effectively. But it would seem to me that the case for the fourth orbiter, exclusive of payload requirements, must be made on the basis of insurance.

Now, if we accept all of that scenario that I just went through, then the question comes down to the funding profile. That simply means, can you fund a new orbiter, the development of the Space Station on the current schedule, the development of a transatmospheric vehicle, a balanced program for space science application, and provide enough money so that we have some experiments to do something useful on the Station—can you do all of that within an acceptable budget for NASA?

And Mr. Administrator, given the overall budget constraints, I think that is going to be a tough bill to pay, and maybe a tough call. So something, I suspect, will have to give somewhere along the line.

BUDGET SUPPLEMENTAL

Mr. FLETCHER. Mr. Chairman, I would like to respond to that. Maybe I am looking at this problem the wrong way, but sometimes when you have an accident as serious as the one we had last January, that is what I consider an emergency. That, as I understand it, is the purpose of a supplemental, is to take care of that emergency.

If we ask for a supplemental, we are asking for a supplemental to take care of that emergency. Unfortunately, we have never had a Gramm-Rudman Deficit Reduction Act before. How do we reconcile a supplemental with a Gramm-Rudman Deficit Act—I don't believe this has been faced by this Congress or by the OMB, either.

So you are right, we are dealing with a very difficult problem. I don't see how we get out of that problem without somehow in either fiscal year 1986 or fiscal year 1987 or some later time, 1988, adding a supplemental just to fix the orbiter. That means we need to fix the shuttle, as Admiral Truly is trying to do now, and to replace the orbiter that was lost.

Beyond that, I hope we come back down to our original budget run out, and that is the purpose, I believe, of Mr. Newman's presentation to you.

GROWTH OF NASA BUDGET

Mr. **Green**. Mr. Chairman, I guess my problem with that is even assuming you had a supplemental that covers the replacement orbiter, the runout numbers that I see here go up at a rate that I think would have been unattainable even without the orbiter accident.

Dr. **Fletcher**. Even without the accident.

Mr. **Green**. In other words, you are trying to get back on the track of one percent growth above inflation starting from your 1984 days, which already eroded these last two years, and, therefore, that calls for growth of 3 percent almost, in fiscal year 1987, close to 2 percent in 1988, and I haven't worked it out, but the numbers seem similar the rest of the way, and if that is going to be the case, we are going to be hard put to do that.

Dr. **Fletcher**. Mr. Green, I can't help but agree with you. I am not familiar with the run-out numbers, the percents, and so forth. That was different before the accident, as you said.

Mr. **Green**. Exactly.

Dr. **Fletcher**. It is because we want to move out into space and have a manned presence in space, which I think is a pretty important thing for the country to do, not just for technology reasons, but for a lot of other reasons.

Mr. **Green**. The problem is this Subcommittee not only wants to move out into space, but it wants to house Americans decently and have decent care for our veterans and it wants to clean up the environment. All of those are calling on our money.

Dr. **Fletcher**. No question of that at all and that is a difficult problem for you. I guess our problem is to try to work what we think is the right thing to do for NASA: to move out into space. I think in the long run if we do it right, Mr. Chairman, the technology spinoffs from this program will feed back into the economy and we will be able to do a lot more with housing and the other things that you want to do. That is a long-range solution and you have to some degree take it on faith, although we haven't made estimates of what the return on that investment will be.

Mr. **Green**. In the end, I think the Administration will have to decide whether it wants us to make the painful decisions or whether it wants to give us some guidance as to what it thinks is the best way to go.

Dr. **Fletcher**. That is probably true, Mr. Green, but let me just say as Administrator of NASA that is a difficult decision for me to make.

Mr. **Green**. I understand.

Thank you, Mr. Chairman.

Mr. **Boland**. The decision is tougher on this side of the table because we have to make the choices between a number of areas in which the Committee is involved, particularly with reference to the housing program.

Mr. **Newman**. It is true in the President's 1987 budget, in which he did meet the Gramm-Rudman targets, that he did provide for growth of NASA that is roughly consistent with the figures we have given Mr. Green.

SPACE SCIENCE AND APPLICATIONS

Mr. **Boland**. Let's turn to Space Science and Applications, and again the justifications will not always be correct.

The original 1987 budget request was $1,464,000,000, which was detailed on page RDSSA-1.

Has that changed in total as a result of the accident, Tom?

Mr. **Newman**. The net change is only about four million. The elements have changed significantly.

SPACE TELESCOPE

Mr. **Boland**. On RD3-4, the space telescope is displayed. Before the accident, it was planned to launch the telescope in October of 1986. I believe last year you indicated that the $113,900,000 shown in the 1986 column would complete funding of the telescope. However, we see some additional requirement for 1987 that was necessitated by a slip from the August to the October launch; is that correct?

Mr. **Newman**. That is basically correct. A year ago, our total estimate for the project was $1,175,000,000. In the budget we submitted to you, it is just under $1.2 billion, so it was a growth of about $20 million.

Mr. **Boland**. Apparently the $25 million requested for 1987 has been increased by $71 million to $96 million as a result of that accident; is that correct?

Mr. **Newman**. That is correct.

Mr. **Boland**. Is that entire increase a result of the accident, or can any of it be attributed to additional overruns involved in the development of the telescope?

Mr. **Newman**. I believe we can say it is attributable entirely to the accident. We would have been within the $1. billion had we been able to launch this summer.

Mr. **Boland**. When is the telescope currently manifested on the 18-month delayed launch schedule?

Dr. **Fletcher**. As I indicated earlier, Mr. Chairman, we haven't decided on the manifest, but we hope to be able to do that soon. I know I am not supposed to remind you about that but we really are working hard on that manifest and I want to make sure you know we are not just sitting idly by.

Mr. **Green**. Entirely apart from the financial cost of keeping your engineering crew going and all the rest, what are the problems in terms of the potential for physical deterioration of this and other sophisticated systems that are on hold notice?

Dr. **Fletcher**. I would like to turn to Dr. Edelson on that, but I think if this hold goes on, there is that danger. My problem and Dr. Edelson's problem is to make sure the team retains the confidence they need to be able to continue on with the program.

The Space Telescope is a very difficult technological program. The group, I call it the team, has got to be convinced that it is important, that it is a national priority, that it has the support of Congress and the President to go on with this program.

Having said that, I would like to turn to Dr. Edelson and see what else we need to do to make sure the team is not going to deteriorate.

Dr. EDELSON. We have problems, Mr. Green, with maintaining hardware in a ready state. We can't just put it in a can and walk away. We have people problems and hardware problems. For example, there are rotating mechanisms on board, control moment gyros and reaction wheels and so on. They have to be exercised. Otherwise, they tend to go flat and get out of balance.

There are continuous instrument tests that have to be performed and also contamination tests and so on. So that takes a crew of people just to guard it and exercise it. In addition to that, we have to retain as much of the engineering force as we can, at least in the key areas. If you are down about a year, it pays to keep most of the crew there. If you are down for two or three years, then it pays to let most of them go and then try to retrain them.

Either one is a very expensive operation. We have calculated the cost for slips of the first shuttle flight of about a year to a year-and-a-half. We are planning for an 18-month slip in the manifest, we will probably launch no earlier than the very end of 1987 or the first or second quarter of 1988.

We are working manifests back and forth between Admiral Truly and myself to come to a launch date. For that type of slip on the average, it would be $6 million per month.

GAMMA RAY OBSERVATORY

Mr. BOLAND. On RD3-6, the Gamma Ray Observatory (GRO) is detailed at a cost of $51,500,000. Last year you told us that the GRO was within cost, totaling about $419 million, and is on schedule. Is the GRO satellite still within cost, or was it still within cost before the accident, and has the accident had any impact on the cost? And, is the launch date still 1988?

Dr. FLETCHER. On the launch date, I had better answer that. It is again part of our manifest problem.

I wouldn't even want to say it is a good bet at this point. Maybe Admiral Truly may want to comment on that.

We really are looking in depth at the first ten launches which takes about the first year-and-a-half and 1988 is part of that.

I wouldn't want to hazard a guess at this point until we have really dealt with the early phases of that manifest.

Mr. BOLAND. I suppose if the manifest slips, the cost will increase, won't it?

Dr. FLETCHER. I am afraid so.

Mr. NEWMAN. As we submitted the budget to you in January it was still within the cost projections. There will be increased costs; I believe the total increase to Space Science and Applications projects is $120 million in FY 1987.

Mr. BOLAND. The accident did not cause the increase, of cost. Is that correct?

Mr. **Newman**. Before the accident the figures were essentially the same as we told you a year earlier. The delay does cause an increase in cost.

Mr. **Boland**. With all of these delays of NASA's scientific payloads, I want to be certain the additional costs are the result of the accident and are not development problems, so we can differentiate between those. I assume you are doing that; are you?

Mr. **Newman**. We are attempting to keep those things separate.

SPACELAB MISSIONS

Mr. **Boland**. On RD3-10, the justifications discuss the 1987 request for $150 million for the Spacelab missions. How many missions were we committed to before the accident, has that number changed or have any additional missions been added since the accident, and how much slip will those missions encounter?

Dr. **Fletcher**. It comes back, Mr. Chairman, to the manifest again and I really have to turn to Admiral Truly on this. I don't know how far downstream we have looked at that manifest.

Admiral Truly, I know you focus mostly on the first year-and-a-half. We will be taking another look at the longer period.

We haven't set the schedule for the Spacelab.

Mr. **Edelson**. I can answer half of the question.

We had eight Spacelab type missions scheduled to fly in calendar years 1986 and 1987. They have to go on the shuttle and they have to go in certain configurations. So if you slip a year-and-a-half, just without regard to anything other than arithmetic, you slip the start a year-and-a-half. Then with three orbiters rather than four, you use a more conservative approach to the build-up of the launch rate. The slip of those eight missions must be three years or greater.

I haven't used anything other than arithmetic to make that change.

Mr. **Newman**. Now, as a result of the slip, we have reduced the Spacelab funds in fiscal 1986 and 1987. We reduced the $108 million to about $89 million in FY 1986 and we reduced the $115 million to about $98 million in FY 1987.

Mr. **Green**. Have you cancelled any missions?

Mr. **Newman**. We have cancelled some specific planned instrument flights which are partial missions, and combined some missions.

Dr. **Edelson**. In going over the schedule and trying to fit them into the manifest, there are two missions that will drop out. One is the re-flight of the synthetic aperture radar. With the slip, we prefer to get on with the development of the next generation instrument, SIR-C.

So we will just drop out the re-flight of SIR-B. The other one is the Earth Observation Missions (EOM). We were planning to do three missions spread out over the years and we decided that a more cost effective way of doing it, because of the slip, is to do two missions and rearrange the instruments.

When you compare the old manifest and the new manifest, the way it comes out those two missions will have been dropped.

Mr. **Green**. Given the costs of mothballing and keeping some of these things going, would it make sense to try to identify those science payloads that don't really have to go up by shuttle and could go by ELV? Even if ELVs are more expensive, abstractly, might the saving of time and cost of keeping these teams make it more economical in the long run to go the ELV route for some of your science payloads?

Dr. **Fletcher**. Before we get into an argument in front of the Committee, Mr. Green, I just want to say, we have not provided any funds in our program for paying for those ELVs. But we need to study them in case they are available from someplace else.

But we are not planning to spend money for those expensive ELVs at this time.

Burt, now you can answer.

Dr. **Edelson**. We were just talking about the spacelabs and they must rely on the shuttle. There are many other spacecraft that we have such as the telescope and and Galileo and the Upper Atmosphere Research Satellite that are presently configured in such a way that they also must fly on the shuttle.

The rest are theoretically possible to go on ELVs and as Dr. Fletcher indicated, we are studying whether we could do it, leaving to someone else to figure out how we can possibly pay for those launches.

MISSION OPERATIONS AND DATA ANALYSIS

Mr. **Boland**. On RD3–14, the mission operations and data analysis line item is detailed. Before the accident, you had planned to spend $68,500,000 for space telescope operations and $69,100,000 on space telescope and refurbishment. That totals almost $140 million for telescope operations and maintenance.

You shifted, as I understand it, some of that money to the development line item that we discussed earlier because of the accident. But what is interesting is that the total operation and maintenance cost of the telescope seems to be inching higher each year. I am wondering whether or not this represents the operating cost of the Space Telescope Institute?

Anybody? How much of this is devoted to the Institute?

Mr. **Newman**. Of the remaining amount which is $52.5 million in fiscal 1987, the Science Institute is about $19 million.

Mr. **Boland**. Are there any other contributions to operating the Institute that you are aware of?

Mr. **Newman**. Not that I can think of.

Dr. **Edelson**. In the 1985 budget there was an increase due to a revised estimate of what the Institute would do and how many people it required to operate it. So we made that change then, and there have been no changes in the scope or activity of the Science Institute in 1986 or 1987.

OPERATING COST OF THE SPACE TELESCOPE

Mr. **Boland**. What do you see as the peak operating cost requirement for the telescope once it is launched?

Dr. **Edelson**. We have categorized in there—I am sorry. We have the operation of the Science Institute itself, the tracking and data analysis activities.

Mr. **Boland**. Just give us the number.

Mr. **Newman**. The operations cost in the years around 1989, 1990 is between $80 and $90 million.

Dr. **Fletcher**. Of course, won't that slip because of the accident?

Mr. **Newman**. Well, it depends. It would somewhat slip although it would build up to that level.

Now, there is also funding for the maintenance and refurbishment and for replacement of instruments in that period which would run another $75 to $80 million.

GRAVITY PROBE B

Mr. **Boland**. Turn to RD3–16, the research and analysis subfunction. We see the Gravity Probe-B definition line item detailed there. Apparently, that program was continued in 1986 at the $9 million level by borrowing money from the Explorer development line item; is that correct, Tom?

Mr. **Newman**. In fiscal year 1986 I think we used some funding from within the research and analysis, but I would have to go back and check that.

Dr. **Edelson**. It did not come from Explorer. It came from the research and analysis and from the shuttle payloads line items.

Mr. **Boland**. We asked for a table detailing all Phase B study funding money for fiscal years 1985, 1986 and 1987. I don't see Gravity Probe-B in that table. I am wondering whether or not the funds detailed here are considered to be Phase B studies. Is that correct?

Dr. **Edelson**. No, sir. This is what we would normally call advanced technology development (ATD). We have in mind a Gravity Probe-B science project which we may fly sometime in the future, which will require a new start.

This is technology development for the very different technology of developing the gyroscopes and so on. And having a test flight on the space shuttle. This will produce no science, just develop the technology.

Mr. **Boland**. Now, the Gravity Probe-B mission is not planning the use of any of the 1987 money for a new start, is it?

Dr. **Edelson**. That is correct. We will carry it as ATD in 1987.

AXAF AND SIRTF

Mr. **Boland**. On RD3–17, the last paragraph, the Advanced X-ray Astrophysics Facility is discussed. Although no numbers are attached to either that or the Space Infrared Telescope Facility (SIRTF), the total we have indicates that $1.4 million will be devoted in 1987 to continuing Phase B studies on AXAF, and $5 million for continued studies on the SIRTF.

Mr. **Newman**. I think we ought to complete that answer, though. There is additional advanced technology work on both of those.

Mr. **Boland**. How much?

Mr. **Newman**. Well, about $8 million on AXAF, and about five on SIRTF.

Mr. BOLAND. The staff, as I understand it, has discussed this with the Comptroller, I believe, but apparently these Phase B requests and Phase B funding are getting totally out of synch with the development start money, which has become increasingly hard to come by.

What happens then is that the contractors put pressure on us to release RFPs for development funding, which we believe should not be done until that funding has been approved.

Are both AXAF and SIRTF now designated as payloads on the Space Station unmanned co-orbiting platform rather than as free flying satellites such as the space telescope?

Dr. EDELSON. Yes, sir, that is correct.

Mr. BOLAND. Is it correct that the AXAF facility will be the first in line under your current plans, and when do you plan to launch that for placement on the co-orbiting platform?

Dr. EDELSON. AXAF, the X-ray telescope, is one of the top priorities for fiscal year 1988 new starts, and we are considering that right now. It would be five and a half years from start to launch. So if we were to start in 1988, it would launch in 1993.

RESEARCH AIRCRAFT CV-990

Mr. BOLAND. On RD3-22, the justification discusses the accident of the research aircraft CV-990. Apparently, last year we had some reprogramming difficulties in connection with the replacement of that aircraft. I gather that the reprogramming procedures were not strictly followed.

Can you tell us about that, and where you are in terms of funding the replacement aircraft and the equipment, and is the money that was assumed in the 1987 budget for replacement of that aircraft still the same dollar level since the accident? What is that dollar level?

Dr. FLETCHER. Mr. Newman, do you have the best guess on that one?

Mr. NEWMAN. First, the amounts we did discuss in the reprogramming are being made available. The aircraft itself was purchased at about $4 million. There are modifications in progress, but at a slower rate than we had planned. The total cost of the modifications are estimated to bring a total for the aircraft and the modifications to between $30 and $35 million.

GALILEO

Mr. BOLAND. Let's look at RD5-1 where the planetary missions are detailed. Galileo, of course, is still suffering and can't seem to get either a launch date that we can live with or maybe even an upper stage if the shuttle/Centaur approach does not work out, owing to safety problems.

The original launch date for this mission was 1982. I understand you hope to launch it on the shuttle/Centaur in December of 1987; is that correct, if all goes well?

Dr. FLETCHER. Well, that is, of course, the best time but as we indicated earlier, we really haven't decided on the manifest. The Galileo launch date is one of the most difficult problems that we have to deal with because of the Centaur problems. It has the RTG problems and so forth. I think it is too early to predict that that is really going to happen in December of 1987.

Admiral Truly, do you want to comment further?

Admiral **Truly**. Yes. The Galileo launch is the principal question on the front end of the manifest because of the vehicle flows and because of the push of the Centaur development schedule. These activities will determine whether or not that December 1987 opportunity or the following summer would be the first planetary opportunity. We are working at that as hard as we can and when we can make the decision on Galileo, we can formulate a manifest because there are a lot of other decisions standing behind that one.

Mr. **Boland**. Now, the budget indicates there was no additional requirement for funds in 1987 before the accident. What would be the total requirement for funding for Galileo if it is launched in 1987?

Mr. **Newman**. Well, we carried $48 million additional in fiscal year 1987, to carry that basically through that fiscal year. So we are running about four to five million dollars a month. If we went to a delta-vega trajectory, there would be another fifteen to twenty million dollars on top of that.

If it is delayed longer than that, of course, the development cost would increase. The development cost in the early years is roughly offset by the decrease in the operations cost so that it is not a net budget increase in the early years, but it is in the later years during the operational period.

VENUS RADAR MAPPER MISSION

Mr. **Boland**. The Venus Radar Mapper Mission is carried at $66,700,000 for 1987. Last year, Dr. Edelson, you told us there were no threats to the total cost of the project, which was about $350 million, and that it was on schedule for launch in April of 1988. That April 1988 launch date was driven by a specific launch window and I believe it was to be launched on a shuttle/Centaur. Is that correct?

Dr. **Edelson**. Yes, sir.

Mr. **Boland**. Has the accident impacted that launch date and, if so, are we still within the $350 million range or has that increased?

Dr. **Edelson**. We are still on schedule. We are still in the $350 million range if the launch date doesn't change. We have had some technical problems with digital units on the radar; however, the program is well within bounds and we are still hoping to launch on that date. That is a Venus window and there are 19 months between windows.

MARS OBSERVER MISSION

Mr. **Boland**. On page RD5-11, the Mars Observer Mission is detailed. The request is $62.9 million for that mission in 1987. Apparently the contract award, which was announced in favor of RCA over Ford Aerospace and Hughes, has caused a protest. The thrust of that protest is that just before the contract award was made, the Jet Propulsion Laboratory issued an order indicating that an integral upper stage would no longer be considered in the selection process.

Why was that done and when do you expect a GAO report on this? You are familiar with that. That was quite a controversy.

Dr. EDELSON. Yes, sir. It was highly desirable to have a separable upper stage because we have plans for further observers after the Mars Observer such as a Lunar Observer and so on. Furthermore, we have other spacecraft coming along in NASA inventory that we would like to fly on an upper stage of that capability. The program office had requested a separable upper stage right along.

As to the second part of your question, I don't know about the resolution of the protest. I do know GAO has met on it and we expected to hear by this time.

Mr. BOLAND. Phil, do you have anything to add on this?

Mr. CULBERTSON. No.

ENVIRONMENTAL OBSERVATION PROGRAM

Mr. BOLAND. On page RD7-1, the Environmental Observation Program activities are listed and on RD7-27, the Upper Atmospheric Research Satellite Mission is detailed.

You are requesting $152.2 million for that activity in 1987. Last year you indicated that the project was within cost and on schedule—for a total cost of about $643 million.

Is that still the case, Dr. Edelson, and is the launch date still 1989?

Dr. EDELSON. Yes, sir.

SCATTEROMETER

Mr. BOLAND. On page RD7-25, the Scatterometer is carried. That was reduced last year from a budget request of $31.7 million to $14 million. That caused a six-month delay in the instrument delivery to the Navy without any immediate impact to the launch date, as I understand it; is that correct?

Dr. EDELSON. The Navy slipped their own schedule and we just slipped accordingly.

Mr. BOLAND. Does the accident impact the $35.9 million requested in 1987?

Dr. EDELSON. No, sir.

Mr. BOLAND. Is the launch date still 1990?

Dr. EDELSON. Yes, sir.

Mr. BOLAND. And has the Navy slipped the program in the last year?

Dr. EDELSON. I understand that that is being discussed. They haven't yet.

TOPEX

Mr. BOLAND. Well, you can expect an announcement.

On RD7-29, the Ocean Topography Experiment is carried. That is also known as TOPEX. The initial request for development is $29 million in 1987. I know you are anxious to proceed with the RFPs before development funding is approved. I think we will be able to advise you one way or the other on going forward with the RFPs, particularly if we mark up this bill some time in the next three weeks.

What is the total cost of the U.S. contribution to this project?

Mr. **Newman**. About $380 to $430 million.

Mr. **Green**. Is there likely to be any delay in this?

Dr. **Fletcher**. No.

Mr. **Green**. Assuming we give you the go ahead.

Dr. **Fletcher**. Not due to the accident, Mr. Green, as far as I know. It is independent of the accident.

Dr. **Edelson**. We are ready to go ahead on that. We are eager to issue the RFP because we have come to a stage in the Phase B development where we want to concentrate on the winning contract.

MATERIAL PROCESSING IN SPACE

Mr. **Boland**. On RD8-1, you are requesting $43.9 million for materials processing in space. The indication that we are getting from some of the Space Station contractors is that the U.S. interest in materials processing in space continues to be very weak compared with the Japanese and the Germans. Why is that?

Dr. **Edelson**. Our interest in materials processing in space is very great, as evidenced by the fact that this particular line item is the fastest growing line item in our budget. We have been upping it about 25 percent a year, which is about as fast as a reasonably oriented program can grow, despite the fact that we have been in difficult budget times.

This is an attractive area and I don't blame the Japanese and the Europeans for being interested in it, but I can assure you, Mr. Chairman, that our interest in it is very great.

Dr. **Fletcher**. Mr. Chairman, I could add a little bit to that, because I happen to have gone over some of that material in my former life. There are many material processing experiments, one of which is for semiconductors. The Japanese, of course, produce most of the gallium arsenide in the world and that seems to be the way of the future for semiconductors.

They also produce a fair amount of the silicon, by the way, for our current semiconductors. Theirs is a defensive strategy. They don't want to lose their market share by any new technology coming along which might come out of the Space Shuttle. So they are very anxious to participate, maybe more so than our own industry, which has lost market share to the Japanese in that particular area.

On the case of biotechnology or whatever you want to call it, biological materials, it is just the opposite. They want to move into this area, as you probably have read in the papers, and they want to take some of that business away from us.

Why our pharmaceutical companies aren't concerned about it is a good question. I would be very worried if I were in their shoes.

Mr. **Boland**. For the record, if you had an additional $20 million for this program, where would you put it?

[The information follows:]

Mr. Chairman, in response to your request, we note that an additional $20 million could be used for the design and development of additional STS equipment with a view towards the adaptability of that equipment to the Space Station Laboratory Module and to provide proof-of-concept for experimental processes and procedures. Examples of areas under consideration for experimental hardware development include: biotechnology, electronic materials, glasses and ceramics, fluid dynamics and microgravity. In addition, the funding could also be used to further increase ground-based laboratory and theoretical research, providing the basic knowledge required for experimental design and operation.

Mr. **Boland**. What was the original request of this activity within the NASA budget deliberations before the budget went to OMB?

Dr. **Fletcher**. Do you have it, Burt?

Dr. **Edelson**. No. I believe we lost very little with OMB in this area. I call your attention to the fact that even in the Gramm-Rudman cuts the 1986 budget went up a million dollars. It is the only area where we actually——

Mr. **Boland**. How about within NASA, internally within NASA? What was the request of NASA before you actually brought it to OMB? Did you discuss it internally?

Dr. **Edelson**. Yes, we did. I think the division director asked for a sum of about $20 million.

ACTS

Dr. **Boland**. On page RD9-1 the Advanced Communication Technology Satellite (ACTS) is detailed. That program was proposed for rescission in 1986 and termination in 1987. As you know, the rescission was not approved and as I understand it, the development of the program is now back on track and is continuing.

Apparently the Authorization Committee included $90 or $95 million for this activity in 1987. Was the budget request to OMB $119 million for ACTS?

Mr. **Newman**. It was $119 million.

Mr. **Boland**. Is the launch date of this satellite still 1990?

Dr. **Edelson**. It was 1989. It now is 1990.

Mr. **Boland**. Is a hundred million dollars required to maintain that launch date or does it require the $119 million?

Dr. **Edelson**. I have got this all down here on the table which I cannot find right now.

Mr. **Newman**. I believe the $95 million would be consistent with the 1990 launch date.

Dr. **Edelson**. Yes, sir. Right.

Mr. **Boland**. I have a little note here indicating in view of the fact this was a Congressional initiative, one of the very few Congressional initiatives ever included in the NASA budget, and in view of the fact this program is now in its fourth year of funding, should not this program have a higher priority than any new start? Is that a fair question or a fair assumption?

Dr. **Fletcher**. I am the Administrator now and I didn't go through all those variations. At this point I think we have to say at the time it was addressed that was considered to be a lower priority than the new starts that came out in the budget. I think, however, because of your urging we need to go back and examine whether or not this is the case.

I don't want to give any wrong impressions. Yes, it is an extremely important program but—and at the time it was a little lower priority than the ones that were started. At this time, however, with your action in the Congress, we had better go back and look at it again.

COMMERCIAL USE OF SPACE

Mr. BOLAND. On RD12-1, the Commercial Use of Space budget is detailed. You are requesting $32 million in 1987 for this activity. It was noted in a piece in *Business Week* dated April 28, 1986, that the great promise that had been hoped for from the McDonnell Douglas Corporation's efforts with electrophoresis and the production of drugs in space has suffered a serious setback.

Apparently, the problem is that drug manufacturing when you look at gene splitting efforts and biotech efforts can be accomplished as effectively and efficiently here on Earth rather than in space.

Is that true and what has gone wrong with this promise?

Dr. FLETCHER. Mr. Chairman, in my former life, I knew something about electrophoresis, too, including magneo-electrophoresis which is a very sophisticated version.

It is always possible in principle to do something on Earth if you discover that it is useful in space. Why this particular company withdrew from that project probably is due to a lot of factors—not just whether you can do things better on Earth than you can in space, but a lot of other considerations.

I will say that the main idea of separating biological material with electrophoresis is to see whether you can get much better separation in space. In fact, some of our earlier experience showed that you could. This was NASA's experience.

Having learned how to do that in space it is also now possible to think, well, maybe there is a way to do that kind of separation better and get those same results on Earth. That does not mean it is going to happen.

It means that they are going to take a look to see whether they can make it happen. Again, I want to emphasize that most of the things that NASA does are experimental in nature. We try to see if we can really do this kind of separation.

Can we get purer biological materials? Having said that, then it is up to the pharmaceutical people to decide which way they want to do that separation. I think that is probably what happened with McDonnell Douglas.

Mr. GILLAM. Yes, Mr. Chairman, that is the case.

McDonnell Douglas still believes they can get a higher purity of material than is capable through genetic engineering here on Earth. So they are proceeding with their activity even though there is a competitive terrestrial process for making the material.

AERONAUTICAL RESEARCH AND TECHNOLOGY

Mr. BOLAND. Let's turn to RD13-1, the Aeronautical Research and Technology areas of the budget where you request $376,000,000. I notice that the research and technology base portion of the budget, which is detailed on RD13-6, is in for a substantial increase above 1986—up from $240,300,000 to $272,900,000.

Is any of that significant increase related to the transatmospheric vehicle work or with supersonic work?

Dr. COLLADAY. Some of the base technology ongoing program in scramjet research, that we have been doing for a number of years, was increased at the beginning of 1986.

Mr. BOLAND. Can you give the figures?

Dr. COLLADAY. It was increased on the order of $5 million from the base of $11 million. That brought it up to a total level of $16 million in the ongoing program in fiscal year 1986, and it has held at that level in fiscal year 1987.

ADVANCED PROPULSION SYSTEMS TECHNOLOGY

Mr. BOLAND. On RD13–38, the Systems Technology Programs are detailed. You are requesting $28,400,000 for Advanced Propulsion Systems Technology. Wasn't that formerly the Advanced Turboprop?

Dr. COLLADAY. Yes, Mr. Chairman, the Advanced Turboprop is the largest of the two programs, that is $26 million of the $28.4. A small part was general aviation.

Mr. BOLAND. What was the request of OMB for the total for Systems Technology Programs in 1987?

Dr. COLLADAY. That was—do you have that, Tom?

Mr. NEWMAN. That is 40 something million for the turboprop.

Dr. COLLADAY. Forty-three I believe; it was reduced 17 million.

Mr. NEWMAN. For systems technology as a whole we asked for $120.1 million as opposed to the $103.1 that is in the budget.

The reduction did relate to the Advanced Turboprop Program.

ADVANCED AERODYNAMICS SIMULATION

Mr. BOLAND. The Advanced Aerodynamics Simulation Activities is requested at $30 million. It was our original understanding that the total cost would be about $150 million, but is that true or will we see simply an ongoing supporting level of about $30 million a year for this activity in the future?

Dr. COLLADAY. The level that is shown at $30 million is what is required to maintain the high speed processor engine, if you will, the driving computational capability at the cutting edge. That funding brings on new processors as they are developed and on the market, ensuring that NASA is always at the cutting edge, doing its pathfinding work, developing new capability, as well as a workhorse role for computational aerodynamics.

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY

Mr. BOLAND. Turn to 14–1, the Transatmospheric Research and Technology area, where you request $45 million. This is, of course, the TAV, which is intended to be anything from a so-called "Orient Express" supersonic transport to a new shuttle.

Do you want to describe to us briefly what you think it is?

Dr. COLLADAY. The research includes $45 million in fiscal year 1987 which is for accelerated technology development, which is NASA's portion of the aerospace plane program. In total, that represents about 20 percent of the total funding. That is leading toward, if all goes well in the technology area, a decision point in the late 1980s. Then you will have another look at the budget implications, and decide whether to go forward with the experimental vehicle.

That in itself is a technology testbed to demonstrate the feasibility of a concept which could lead to operational vehicles that cover a wide range of applications including hypersonic transport, single-stage orbiter, or military intercept vehicles. It is in the classic sense an experimental vehicle program, as we have done for many years in aeronautics, that establishes the feasibility.

It is not an operational vehicle or a prototype.

Mr. GREEN. Are you limited just to engine research at this point, or are you doing other things?

Dr. COLLADAY. No, Mr. Green, the engine is certainly the most critical of the technologies and has a high priority in this next three years of technology development. But there is also work on advanced structures development and advanced computational fluid dynamics code development. I might add that those three things are also applicable to advanced transportation systems across the board, whether they be for this vehicle or other systems.

Certainly propulsion is the key highest priority in that area, but it is not limited to that.

Mr. BOLAND. This is a new program, of course.

Dr. COLLADAY. It is a continuation of a lot of work that has been going on in the NASA program. It is new in the sense that we have laid out our program with some decision milestones and commitments for the next vehicle.

Mr. BOLAND. Is it a Presidential decision to get into this kind of activity?

Dr. FLETCHER. It was announced as a Presidential decision, Mr. Chairman, but what Dr. Colladay is saying is that from our point of view, it is an extension of a technology that has already been going on and that is going to be our main contribution. We are not the program managers of this program, but we are very active in all elements of the management of the program.

NASA/DOD FUNDING OF TAV

Mr. BOLAND. The arrangement, as I understand it, is a split of 80-20 between Air Force costs and NASA costs in this project. Is that right?

Dr. COLLADAY. That is for R&D. That doesn't include the resources that we bring from the institutional funding of NASA Research Centers involved in the program, for example, the use of the computers and wind tunnels that are available.

Mr. BOLAND. The Air Force is aboard on this project?

Dr. COLLADAY. Yes, sir.

Mr. BOLAND. Keep them aboard.

What is the total cost of the initial phase of the program? I understand it is something on the order of $2 to $3 billion?

Dr. COLLADAY. Well, this next phase of the program is $600 million for the accelerated technology development. That ends in a decision point to go for the experimental vehicle which will be in the late 1980s.

Mr. BOLAND. What constitutes the initial phase, if you add up everything in the initial phase. Does it come to between $2 and $3 billion?

Dr. **Colladay**. No, between $2 and $3 billion would be the cost all the way through the experimental vehicle.

Mr. **Boland**. All right.

Dr. **Fletcher**. Up to first flight of the experimental vehicle.

Dr. **Colladay**. Through first flight. That is for two vehicles plus spares and through a flight program that would end in the mid-1990s. That is the budget estimate for that entire program.

Mr. **Boland**. What was the request of OMB for this activity?

Dr. **Colladay**. We were negotiating the program content and definition of the program at the time we were also negotiating the budget with OMB. The original request was $30 million, and during the process of negotiation it was increased to $45 million.

Mr. **Boland**. Now, is the split in 1987 actually on the basis of [illegible] 20, or is NASA paying more than 20 percent?

Dr. **Colladay**. If you include the operations costs of our h[illegible] speed computers, for example, the NAS, Numerical Aerodynamic Simulation system that will be used, as well as the wind tunnel tests, the indirect costs will increase our investment over 20 percent, but in the R&D budget alone it is 20–80.

Mr. **Green**. So the DoD share for fiscal year 1987 is $180 million?

Mr. **Newman**. No, $150 million. Dr. Colladay was saying the $45 million, which is the direct start, share. Their share is about $150 in fiscal year 1987.

Mr. **Green**. That is not 80–20.

Dr. **Colladay**. The 80–20 was the estimate of the entire program.

Mr. **Newman**. It runs all the way out, and it is 80–20 for that.

Mr. **Green**. I am just wondering why the first year is different from all other years?

Mr. **Newman**. The total for fiscal year 1987 is $212 million, of which NASA's part is $45 million in the systems technology line, plus the $17 million, in the R&T Base that I referred to first for a total of $62 million. The Department of Defense total is $150 million, split between DARPA, Air Force, SDIO and Navy.

Dr. **Fletcher**. Mr. Green, you can expect us to be a little higher in the front end of the program because we have a running start on the program and perhaps a little less at the end of the program.

Mr. **Newman**. We have a role in the technology in the early part of the program.

Mr. **Green**. I am wondering just how much commitment you have, because there were press accounts that as of April 7 DARPA had let contracts which were variously described as having a prospective value of more than $450 million for research work on this effort.

Dr. **Colladay**. In the DoD budget is $150 million for fiscal year 1987, $45 million in 1986, and $285 million in fiscal year 1988. Those resources are sufficient to cover the principal contracts. In addition to that, there is a lot of supporting technology development that needs to be done and that is principally what NASA comes in with.

TAV CONTRACTS

Mr. **Green**. So you are not funding those $450 million of contracts that were announced on April 7?

Dr. COLLADAY. Those contracts are funded with DOD resources in FY 1986 but we are sharing in a joint program where the resources of NASA and the Department of Defense together are being used. Primarily the contracted efforts referred to in that press release are using all DoD funds in fiscal year 1986.

Mr. GREEN. I have heard projected estimates—obviously these have to be very rough—of this ultimately turning into a $20 billion program once you get past the first plane and get it on the runway to take it off, and develop it.

Dr. COLLADAY. Let me put that in perspective. What we are talking about is a technology development program through an experimental vehicle. That is just to provide the options and the basis for a decision of whether to go forward with developing an operational vehicle or vehicles, whatever the application might be. The $3 billion estimate is what would be required to carry it through the experimental vehicle.

Then developing operational systems, full development costs, would be in addition to that. Those estimates are if you build hypersonic transports and launch vehicles and military interceptors, $20 billion is probably not unreasonable and in fact, it is probably low.

PROJECTED USES OF TAV

Mr. GREEN. I guess I get a little nervous every time I am told a system can do so many things, remembering the F-111, and the FA-18.

Dr. FLETCHER. Mr. Green, I think it is important to recognize that after that experimental vehicle is flown and we learn from it, there are at least three ways that you can go from there. Each of those three ways is going to be different. You can't make one device do all three missions. That ought to be pretty clear to this Committee at this point.

If we go to an Earth-to-space vehicle, that is one kind of an application. That will not be the same thing as a hypersonic transport. It will be a completely different vehicle.

That is the first time I heard of a fighter application.

Mr. GREEN. No; bomber.

Dr. FLETCHER. Bomber application. But that would be different.

Dr. COLLADAY. Well, reconnaissance or interceptor vehicle. But the technology takes a different application, as Dr. Fletcher said, a single vehicle wouldn't be an all-purpose vehicle to do all those things. The technology will spin off so that a number of vehicles would have the same common pedigree in technology going back to the experimental vehicle.

Mr. GREEN. Let me ask this: If it was NASA's choice to decide alone on allocation of resources for aeronautical and space vehicle research without the defense implications, would you have picked this on which to put so much resources, as opposed to the other things you are doing?

Dr. COLLADAY. I think it is one of those classic breakthrough areas in aeronautics and space technology, and it draws on both. In the sense that we put that as our principal objective of pushing those kinds of advanced technologies, I think it is the right thing to invest in with its tremendous potential. It is one of the revolutionary steps that come along rarely when all the pieces fit together. And while there is a lot of risk in this program, by no means are we certain that we will be able to accomplish it. It is worth, I feel, going after because of the potential payoff.

Mr. GREEN. Given the uncertain stage in which the program is at this point, how much confidence do you have in the $3 billion figure?

Dr. COLLADAY. I think the $3 billion figure is fairly accurate for our estimate built on what previous costs have been in other experimental programs, and basing the cost estimates on that, I think we can do the program for that.

RISK PERTAINING TO TOTAL COST

Mr. GREEN. Can you quantify the risk that it will cost more? A percentage? One-third? Is that a possibility? Twenty-five percent?

Dr. COLLADAY. The technology is extremely risky. We have tried to make provisions for that risk in the estimate of the total cost. A lot will be clarified in terms of what those risks really are over the next three years as we pursue the technology development high-temperature materials and propulsion activities. That is why we put that decision point there with another budget decision in fiscal year 1988, for the 1989 budget.

Mr. GREEN. I guess my problem is I see an agency in a very tightly constrained budget situation, one that will be staying constrained for the next five years, biting off an awful lot of potential for expanding beyond our ability to finance it.

Dr. FLETCHER. Mr. Chairman, Mr. Green, I don't really know all the purposes of this particular experimental plane, but sometimes it is good for technology, such as aeronautics R&D which we have been pursuing for some years—actually, the hypersonic technology started before I left. Sometimes it is important to bring it all together in kind of a focus.

I don't think we are talking about large funding from NASA, but we are talking about somewhat of a redirection of our resources in terms of R&PM, people and facilities, and that is not a bad way to go in terms of focusing a particular kind of technology.

Having said that, Dr. Colladay, correct me if I am off base on that.

Dr. COLLADAY. No, I agree with that. It is appropriate when technology comes along that is this revolutionary to focus our attention and resources within the ongoing program as well, to achieve objectives like this. The costly part of the program will be in the development of the experimental vehicle, and that is the responsibility of the Air Force, just as it was in the X-15 and other major experimental vehicles that we have done in the past. In fact, we have taken a chapter right out of the history book on this program, from the X-15. The Air Force was the procuring agent, and NASA, NACA then, was the flight test agency.

Mr. GREEN. Thank you, Mr. Chairman.

Dr. GRAHAM. If I can add one comment, Mr. Green.

I certainly understand your concern over the budget constraints. There is another way to look at this particular program. There have been a few revolutionary areas in the development of aeronautics and space technology; certainly the development of the jet engine was one. The development of the rocket engine technology, particularly the rocket engine itself, was another.

There is always a tendency for organizations, large organizations, to improve on existing technology in incremental ways and tend to shy away from revolutionary technologies.

Mr. **Green**. I guess my feeling is that that has not been the fault of NASA. It has been the other direction.

Dr. **Graham**. Some of NASA's antecedents have been criticized in that very area, in fact, and it takes an effort to look for revolutionary technologies and to lay out programs which are responsive to pursue those. Yet, obviously it takes substantial promise as we get into working the technologies to make us willing to pursue this with larger funding levels.

If that much promise is shown—and I certainly hope it is—it will be a boon to transport to space and probably to the cost to transport to space and quite possibly to other long-haul technologies such as eventually long-haul transport from point to point on the earth.

Even if the technology proves to mature more slowly than that, however, the advances that we are already seeing as the first precursors in terms of high temperature materials, numerical aerodynamics, and other areas, will have considerable application to more conventional technologies of today, such as rocket technologies. We see this program as holding great promise and, in fact, giving us a potential for a competition in a launch to orbit vehicle between airbreathing technology and a rocket technology, both of which have been taking advantage of many of the developments that we foresee in this program. That competition, in itself, will advance our technology and in the long run lower our cost to orbit.

So, for all these reasons this looks like a very appropriate program to pursue, and frankly I hope it is so successful that it eventually justifies considerable resources.

Mr. **Boland**. What would you think the 1988 budget would carry for this program?

Dr. **Colladay**. The 1988 budget estimates are, at this point, $74 million for the NASA portion.

COMPLETION OF EXPERIMENTAL PHASE

Mr. **Boland**. Did you indicate when the experimental phase of this program would be completed?

Dr. **Colladay**. It is in the 1992 to 1995 time frame for the flight testing.

Mr. **Boland**. And NASA's costs will increase, of course, over the next five years—substantially, I would think, each year?

Dr. **Colladay**. Yes, although in the phase that we are currently in with the budget here, it doesn't exceed a level of about what I just quoted.

There is another budget decision point in the beginning of Phase 3 which is the vehicle phase.

SPACE RESEARCH AND TECHNOLOGY PROGRAM

Mr. BOLAND. On RD15–1, you have the Space Research and Technology program; you are requesting $180.2 million. On RD15–35, the largest increase appears to be occurring in the chemical propulsion technology systems line item, and in the control of flexible structures flight experiment. The latter activity is jumping from $5 million in 1986 to $11.3 million in 1987.

What is the total cost of that experiment, and are those experiments intended to fly on the shuttle? Will the accident delay those flight experiments?

Dr. COLLADAY. The control of flexible structures experiments have a number of elements to them. There are Phase 1, Phase 2, Phase 3 that are in the planning stages right now with a number of investigators doing ground-based research. They have been impacted by the accident. I don't know what the date for flight will be now.

Originally they were manifested in 1991, so they were fairly long range in nature, and they will probably be slipped further. The first of the experiments is a 60-foot mast, which we will instrument and begin to understand the dynamics of large systems and their active control. That is modified in the Phase 2 of the experiment to put a dish on the mast and get more sophisticated in the control systems. And then Phase 3 is a more complex system.

We see this as a line item that will support follow-on engineering experience in control of large, flexible structures with a number of re-flights of that hardware.

Mr. BOLAND. What is the total cost of the experiment?

Mr. NEWMAN. The total cost projected from 1988 through 1991 is about $65 million, in addition to the $11 million in 1987 and the $5 million in 1986. But that is for several experiments.

AUTOMATION AND ROBOTICS TECHNOLOGY

Mr. BOLAND. You are also showing an increase in the automation and robotics technology program from $10.2 million to $18 million.

What was the internal request, within NASA, for that activity in 1987? Do you get in on the internal requests, Tom?

Mr. NEWMAN. Yes, I do.

Dr. FLETCHER. He gets in on everything, Mr. Chairman.

Mr. BOLAND. Do you know what it was?

Mr. NEWMAN. I am trying to remember. I think essentially——

Mr. BOLAND. Nobody ever remembers what the internal request is. Everybody remembers what the request of OMB was.

Mr. NEWMAN. I don't believe we cut this significantly, though.

Dr. COLLADAY. I believe it was a doubling rather than 80 percent increase; we were looking at $20 million, and a run-out level of $25 million. I have been working with on a 10-year program of roughly $25 million a year. So, we are building it up rather rapidly.

Mr. BOLAND. Would you mind, Tom, if we quit now?

Mr. NEWMAN. That is all right with me, sir.

Mr. BOLAND. How about John? Do you mind if we quit right now?

Mr. HODGE. Okay.

Mr. **Boland**. Okay, we will be in our cozy, little room, Tom. So when you join us tomorrow, join us over in H-143, and we will be happy to see you. Hopefully we can complete it in one day.

You would like that, wouldn't you, Phil?

Mr. **Culbertson**. That is all right.

Dr. **Fletcher**. I thought you meant quit-quit. You just mean recess, Mr. Chairman.

Mr. **Boland**. So, we will stand adjourned until 10 o'clock in the morning. There will be no mikes, no cameras, and nothing else; just people.

WEDNESDAY, MAY 21, 1986.

TRACKING AND DATA ACQUISITION

Mr. BOLAND. Well, we have a nice morning to proceed here. The Committee will come to order.

This morning we will finish up this volume of the justification. We will be looking at the Tracking and Data Acquisition that is carried on page SF3-5.

Last year, following a suggestion by NASA, the Congress reduced the payment to the Federal Financing Bank by $107 million. That amount represented the principal payment to the FFB for the Tracking and Data Relay Satellite System. That reduction was actually a "paper" cut because ultimately that payment will have to be made to the FFB. Is that correct?

Mr. NEWMAN. That is correct.

Mr. BOLAND. Does the 1987 request of $301,500,000 on SF3-4 include all interest from principal payments to the FFB?

Mr. NEWMAN. It includes payments to the FFB of $227 million which is the interest and principal that is due in fiscal year 1987.

Mr. BOLAND. The Congress capped this program at $2,800,000,000. Is that the current correct figure?

Mr. NEWMAN. No. In the operating plan letter that we sent in January we stated that that ceiling would have to be adjusted. At that time we——

Mr. BOLAND. I am talking about the $2.8 million.

Mr. NEWMAN. $2.81 million is the current cap. We now propose a cap of $2.915 to account for the delay of payments.

Mr. BOLAND. So you are increasing this by a hundred million, to $2.9 million?

Mr. NEWMAN. That is our estimate as of January. There may be some additional impact as a result of the shuttle delays. And Bob Aller is prepared to answer that.

Mr. ALLER. Allow me to comment if I may.

Mr. BOLAND. Would you comment?

Mr. ALLER. The amount Tommy is referring to is $120 million over our runout last year which didn't change. It is made up of two segments of interest, both about $60 million.

Sixty million dollars of that is associated with withholding of $77 million principal in 1986 and the other $60 million is that we had prepayments that we had discussed with your staff and the Senate in both 1986 and 1987. Those withholding of payments adds about $60 million in interest also. That is the $120 million.

Prior to the accident, the growth in the program had been in interest alone based on those actions.

We have not fully evaluated the results of the loss of TDRSS in the January accident, but we estimate about a $3 million a month impact. I should explain that.

We were on a launch schedule for January of 1986, July of 1986, and March of 1987 for the next three TDRSS launches.

We are still looking for three launches, of course, to replace those three, and at about $3 million a month, if one assumes a 20-month down time that is about a $60 million impact. That of course will be determined when we have a final manifest as to what the total impact of those three launches will be.

REPLACEMENT OF TDRSS SATELLITE

Mr. **Boland**. Does the revised 1987 NASA budget include $39 million for the initial payment on a TDRSS satellite to replace the satellite lost on the Challenger?

Mr. **Aller**. The submitted budget does not. The revised budget that raises our request of $816 million overall to about $890 million includes the impact in 1987 of the accident. About half of that, about $39 million, is for long lead items for replacing of spacecraft.

The other half, about $40 million, is made up of the extension of the ground stations which we had planned to close down this June and we, of course, will have to extend those until we get back on line with the TDRSS program.

Mr. **Boland**. Does that $39 million reflect that any purchase of additional TDRSS satellites will now be handled on-budget?

Mr. **Aller**. Yes, sir. That is correct.

Mr. **Boland**. The original plan was to have six satellites—three operating in orbit, one on orbit spare, and two backups; is that right?

Mr. **Aller**. That was the original plan, yes, sir. We revised that slightly in 1982 when we modified the contract to reduce the number in orbit to three. At that time you may recall we went to a total Government system and were able to reduce that—keep that fourth spacecraft on the ground. We are still looking for a three in orbit configuration for supporting government use. That will be the next three launches.

We have one up there operating, you recall——

Mr. **Boland**. Do I understand you are not requesting funding to replace the lost satellite?

Mr. **Aller**. Yes, sir, we are.

Mr. **Boland**. Why do we need to spend scarce dollars to replace the lost satellite?

Mr. **Aller**. The present system we estimate will provide support through about 1993 or 1994. That was on the basis of six spacecraft. We are now down to five plus the rather sick one we have in orbit that was the result of that first launch back in 1983. What we are looking for is to assure ourselves we have a ground spare during the early 1990s when we would have potentially launched the remaining four spacecraft. With no spacecraft on the ground, of course, then we would not be able to continue this system from then on because we would have no means of replenishing the spacecraft.

Our plan before the accident was to start spacecraft development for about a 1994–1995 delivery of three spacecraft. We have had to revise that plan to go for an early procurement of a replacement spacecraft, and parts for two more. We are delaying a planned 1994 buy to about 1996–1997 on a competitive basis for three additional spacecraft. That should carry us through about 2000 and beyond.

The accident simply has required us to fill in the gap so we are assured we have enough spacecraft through about 1994 or 1995.

Mr. **Boland**. Would the replacement satellite be a sole source to TRW or would it be competitively bid?

Mr. **Aller**. We have not totally resolved that, sir, but we are looking primarily at a sole source approach.

SHUTTLE IMPACT TO TRACKING PROGRAM BUDGET

Mr. **Boland**. Can the cost of the 18-month delay be absorbed from within the $798,900,000 request for Tracking?

Mr. **Aller**. No, sir. The $798,900,000 was our estimate before the accident and what we are asking for in 1987, I think, is $74 million more than that. That $74 million again is this added spacecraft which we had to move those dollars ahead for and retention of the space ground stations.

Mr. **Green**. Mr. Chairman, if I may.

Mr. **Boland**. Yes.

Mr. **Green**. You have increased from the original $795 million to $2.9 billion. Could you split that increase between interest on the one hand and overrun on the other?

Mr. **Aller**. Yes, sir.

The principal that we borrowed from the bank until two years ago when that loan ceased, was about $1.1 billion. The interest on that is about $1.1 billion. So we have $2.2 billion in that area.

If you want to talk about what is the increase, in interest our original estimate on interest was $220 million, and we ended up at about $1.1 billion. We have had a cost increase of about 150 percent in the program over these years for many reasons. And we have had delays in the program which is an additional $350 million cost in delays.

Our original launch was scheduled in 1980 on shuttle. I should really go back just once more. When the program was initiated in 1976, the first three spacecraft were to be launched on Atlas Centaur. That was changed in 1979 to all on shuttle. All on shuttle and IUS.

We had the difficulty of bringing along a new spacecraft, a new IUS stage and a new shuttle. That first launch was delayed then to 1983. We have had some delays since then, so there has been considerable delay cost.

Mr. **Green**. Thank you, Mr. Chairman.

Mr. **Boland**. Larry?

COMMUNICATIONS SATELLITES

Mr. **Coughlin**. Thank you, Mr. Chairman.

I have some questions on a number of things.

Mr. **Boland**. Sure, that is all right.

Mr. **Coughlin**. I had to go to Pennsylvania for the election day yesterday. I apologize for not being here.

The Federal Government appears to have a strong interest in research and development that affects new commercial development in space. Is it not essential that we maintain our technological lead in the one commercial industry that emerged from NASA's research, communication satellites?

Dr. **Fletcher**. Well, I can start with that, Mr. Coughlin.

As you know, we have pioneered in the development of commercial satellites with the first, I think it was called Relay, then the Syncom followed. Those were NASA launches and were partially supported by the companies that were involved.

They have carried on very well in the communications satellite area, and they are, in the standard satellites, way ahead of us.

On the other hand, they have not carried on in the so-called broadcast satellites in some higher technologies because they are doing all right with their older versions.

So, yes, we have an obligation to the commercial satellite business as well.

Mr. COUGHLIN. How much money has NASA invested in communication satellite development over the years? It is my understanding the total figure over some 25 years is well under $1 billion. Yet it is an industry that generates $5 or $6 billion annually as a result of these efforts.

Dr. FLETCHER. I cannot answer that question, Mr. Coughlin. Maybe Tommy can supply it for the record.

Mr. NEWMAN. Sure.

[The information follows:]

Since the agency's inception, NASA has spent about $600 million real year dollars (or $1.7 billion in FY 1986 dollars) on communication satellite flight development programs. These include the Echo program, the Relay program, the Syncom series, the Applications Technology Satellite program, NASA participation in the Communications Technology Satellite, and the current funding to date for development of the Advanced Communications Technology Satellite.

Dr. FLETCHER. Mr. Newman can supply it, but I can say that in 1974, there-abouts, we had a severe budget crunch which you may remember. Even though it was important that we carry on this work, we had to cut back on the development work in communications satellites and it is my understanding that that was revived again when Dr. Edelson came aboard and the ACTS was one of the first initiatives that came out of that.

ACTS

Mr. COUGHLIN. You acknowledge the next generation of satellites were built with ACTS-like technology, that is also being developed by several other foreign countries. Do we intend to pursue development of this technology and in cooperation with other countries or on our own?

Dr. FLETCHER. I would look to Dr. Edelson to answer that.

Dr. EDELSON. That would be strictly on our own, Mr. Coughlin. The goal of the ACTS project is to maintain and advance U.S. technological leadership. So, unlike every other project we have in the science program, in this particular applications program we have restricted it to U.S. participation.

Mr. COUGHLIN. And do you have any unobligated balances of funds that can be used to fund ACTS for fiscal year 1987?

Mr. NEWMAN. No, we don't have the funding for 1987 in the budget. We do have the money to continue through 1986.

Mr. COUGHLIN. Just through 1986?

Mr. NEWMAN. You remember the rescission was not approved, so we do have that money, for fiscal year 1986.

SPACE SHUTTLE MANIFEST PRIORITIES

Mr. **Coughlin**. I discussed at some length the shuttle program on the first day of the hearings. I would like to go back to that for one minute. It has been stated that perhaps as much as two-thirds of shuttle flights in the future would be devoted to defense satellites to deal with the backlog of Pentagon payloads as a result of the shuttle accident.

In your opinion, will our defense communications capability suffer if there were to be a better balance between the commercial and defense payloads?

Dr. **Fletcher**. Mr. Coughlin, I don't see that to be a major problem except in the near term. In the near term, for the next fourteen months, we won't be flying at all. So something has to be done by somebody else.

There aren't that many expendables around so there are going to have to be priorities on expendables, too.

Once we start to fly again, we still have a problem because we, first, have only three orbiters, second, we are going to be very careful about how we use those three orbiters and, third, the flight rate is going to be somewhat constrained.

We are in the middle of putting together the manifest for the first year or so which is going to be a big problem. A lot of people are going to get angry with us for whatever we decide.

We get back to four orbiters again, but that is also in question at this time because we don't have a supplemental from either the Congress or the White House to replace the orbiter that we lost. All I can say is we are going to have to have a balanced program. The military cannot dominate nor can commercial, and we have not decided any of those questions at this point.

Having said that, however, there are discussions going on in an interagency group between Defense, ourselves, Commerce, and the Department of Transportation on how we can get a commercial launch vehicle program started. That looks like it is two months away at least, maybe longer. So no decisions have been made on that subject.

COMMERCIAL ELV PROGRAM

Mr. **Coughlin**. And in connection with the commercial program that is being developed within the Department of Transportation, which happens to be in my other subcommittee, would you comment on how NASA looks on that? That is strictly a private effort.

Dr. **Fletcher**. Mr. Coughlin, that is a policy issue on the part of the Congress and the Executive Branch. It is my understanding that both the Congress and the White House have an input on making a decision to do whatever is necessary to get a private commercial ELV program going.

The discussions revolve around the best way to do that. It is going to cost a lot of money. We have to decide where that money will come from. Things of that sort have to be put into the picture before we can decide how to go ahead with the commercial ELV program.

Those estimates depend on what we estimate the number of commercial payloads are going to be over the long-term. We know the near-term reasonably well. The long-term is the penalty that the taxpayer has to pay to get this new commercial ELV program started. All of those corporations have to go into the decision process as to how we best, from an economic point of view, get that program started.

Mr. COUGHLIN. I recall the days many years ago, the cost benefits of the shuttle really depended to a large extent upon extensive commercial activity.

Are we going to lose the cost benefit of the shuttle if we do that, if we go to a private program?

Dr. FLETCHER. Mr. Coughlin, I think we will if we have the capability of launching commercial satellites and we decide for some reason not to launch some fraction of them. Of course, that will not only reduce the cost effectiveness of the shuttle, but it will increase the cost to the government; that is the penalty I am talking about.

If we decide not to—I don't think we are ever going to decide not to launch any commercial satellites, because some of them are designed for the shuttle, but let's suppose we reduce the number of commercial satellites that we launch on the shuttle. That is just not cost effective, even though back in 1972 we made some errors about the number of flights and so forth, the shuttle is still the most cost-effective way to launch all payloads.

But the question is, should we have a back-up for commercial satellites and a back-up for defense satellites and then how much is that back-up going to cost? And those are the economic considerations that have to be made. It is still true, Mr. Coughlin, that the most cost-effective way to launch all of those is through the space shuttle.

Unfortunately, we only have three orbiters, so we are not going to be able to do very much for the near-term. If we have four, even then we will be restricted, but as I have said many times before, we really ought to have five. Unfortunately, that was decided before I came back. At the present time, we are fighting hard just to get the replacement orbiter. Until that happens, we are going to be tight on all launches.

DUPLICATION OF NASA/AIR FORCE FACILITIES

Mr. COUGHLIN. I have previously expressed some concern about the duplication of facilities. The Department of Defense has established a space command out in Colorado that would appear, to some extent, duplicative of the mission control in Houston and some other facilities that NASA has.

Do you view these as duplicative or redundant?

Dr. FLETCHER. Mr. Coughlin, they are not completely redundant. It is my understanding, and I have been a little bit on the other side of that argument, having spent part of my private years consulting in the Defense Department—they look at that as a special need that they have certainly for classified payloads. Even though it is redundant, it is a necessary redundancy from their point of view.

If everything was out in the open and we had one merged program, civilian and defense, there might be some cost savings there, but I think it is a legitimate thing for the Defense Department to do.

Mr. COUGHLIN. Those classified launchings couldn't be done by NASA?

Dr. FLETCHER. I wasn't involved in the negotiations, Mr. Coughlin. I am not sure anybody present was.

Mr. CULBERTSON. I was.

Dr. FLETCHER. Phil was there, yes. You might be the best authority on that subject.

I know there were a lot of negotiations that went on. They had started even when I left in 1977. I don't know how they finally ended up.

Mr. CULBERTSON. Well, up until this time we have carried out all the launches, of course, and there have been classified and unclassified missions that we have flown.

The thing that is redundant that is being provided by the Department of Defense is the mission control center kind of activity and some training capability and mission planning.

We made modifications and additions to the capability at Houston in order to provide a certain level of security in some areas necessary for certain missions, before the Air Force made its decision to have a capability of their own.

And more would have been required at Houston had the Air Force not decided to develop some of the kinds of capability they have done out in Colorado.

The concern that always was expressed to us as we negotiated these was both the difficulty of maintaining an adequate security level at Johnson, which is, generally speaking, an open facility, and the concerns they had about security. More importantly, the Air Force desired to have control over their own shuttle missions.

There was another concern that came into all the considerations and that was that there was no redundancy at all in our ability to have a mission control function. Without that there was no redundancy other than the single capability we had at the Johnson Space Center.

And in the event of some kind of problem down there, that we could not fly, the Department of Defense wanted that kind of robustness in the mission control functions.

So, Dr. Fletcher is right that in some cases the Colorado facility is redundant. In some cases it is additional capability that would be necessary to put either at Johnson or someplace else that was required for the DOD missions. And it was decided to put it in Colorado.

FUTURE USE OF SHUTTLE

Mr. COUGHLIN. I guess I become worried about where NASA is going. The payloads are becoming increasingly military, and the mission control is being developed by the Defense Department, and we are going to privatization of commercial launches.

I am not sure where NASA is going to be in a few years.

Dr. FLETCHER. Mr. Coughlin, that is always a concern.

On the other hand, the shuttle, as you well know, having served in your current assignment for some years, is a transportation system for everybody: science, the Defense Department, the commercial payloads, and any other thing that can be done on the shuttle like materials processing. We don't plan to abandon that role of the shuttle. The shuttle now an additional reason for being, a NASA space station, and that has to be phased into the thinking. The space station has to be assembled and operated through the use of the space shuttle. With an adequate number of orbiters we can still do all those things and probably should, to the extent we have the capacity to do so. But that, again, is kind of a mish-mash that is trying to be dealt with by the interagency group.

Now, having said that, it is quite clear now that the Defense Department will off-load some of their missions from the shuttle in the near term. That is absolutely necessary with only three orbiters. They have to do that. Even when we get back to four orbiters, they may continue to do that to a larger extent than we had thought was going to be the case.

We originally thought two ELV launches per year was a reasonable number for the Defense Department. That is probably going to go up some. It is still probably going to be true that we are going to launch a large number of military payloads on the shuttle. That doesn't mean they are going to dominate. That doesn't mean that the STSOC, or whatever they have in Colorado, is going to run all the shuttles.

It is only their missions that will be run out of that facility. So, I think it is pretty clear at this point that we are not terribly different from where we were when we started the space shuttle program, except for the fact that expendables are going to have more emphasis than they were when we started. That much is clear.

But it doesn't change the mission of the shuttle in a major way.

Mr. COUGHLIN. I am fighting for you, you know.

Thank you, Mr. Chairman.

CONSTRUCTION OF FACILITIES

Mr. BOLAND. We will turn to Construction of Facilities. The request for 1987 is reflected on page SUM-4.

You are asking for $181,300,000 as compared to $139,300,000 originally appropriated in 1986.

The 1986 number, of course, does not reflect the 4.3 percent reduction occasioned by the Balanced Budget and Emergency Deficit Control Act of 1985.

Did you apply the 4.3 percent across-the-board to all projects?

Dr. FLETCHER. Mr. Newman.

Mr. NEWMAN. No, we applied the 4.3 percent to the program as a whole, and we took the amounts in selected areas where it could be taken, primarily, I believe, in the minor projects.

General McGarvey.

General MCGARVEY. We did, Mr. Chairman, take the reductions in most cases from our contingencies for the discrete items that normally carry a contingency of 10 percent. In most cases we reduced that to 5 percent, except in specific cases where there were cost problems, and we were able to tax one project at a higher rate to offset one that needed the funds as opposed to the other project.

The reductions averaged about 3.7 percent against the minor projects, and then reductions at about 5 percent in the discrete projects in order to come up with 4.3 percent.

Mr. **Boland**. General McGarvey, your budget was put together before the accident, wasn't it?

General **McGarvey**. That is correct.

Mr. **Boland**. Given the fact there is going to be an 18-month slip rather than a 12-month, and even that 18-month slip could be rather optimistic, I presume there are some projects in your request for 1987 that could be slipped. Have you looked at that possibility? If so, what would be the resulting savings?

General **McGarvey**. We have looked at that, Mr. Chairman, and really there aren't any projects that could be slipped as a result of the accident.

Mr. **Boland**. I take it the accident had no impact on your facilities?

General **McGarvey**. It has had one adverse impact. That is an engine test stand at NSTL, a 1985 project which we initiated. We have not been able to gain access to the stand to do the actual installation of the modifications to convert it to a single engine test stand because of the delay in the main propulsion test.

The accident has aggravated that situation and pushed the cluster testing further downstream so we will be confronted with terminating the present contract and probably having to reprogram later in order to provide the additional single engine test capability at NSTL.

CENTRAL COMPUTING FACILITY AT JSC

Mr. **Boland**. On page CF1-2, the Johnson Space Center, you are requesting $9 million for construction of a central computing facility.

In the list which you provided last year, your request for construction projects submitted by the centers and supported by the program offices, but which NASA did not submit to OMB, this project was not listed. Two other projects were on the list which I presume must have enjoyed a higher priority.

What about that?

General **McGarvey**. Yes, sir, it did not survive the internal NASA reviews last year. It was a candidate item in the NASA internal reviews, but we did not submit it to OMB because of higher priorities at that time.

CENTER PROJECTS NOT SUPPORTED BY NASA

Mr. **Boland**. I am reading from page 175, "The following is a list of projects submitted by the centers and supported by the program office which did not make the OMB submission."

And it is not on this particular list.

General **McGarvey**. Yes, sir. The list that we gave you says, "The following is a list of projects submitted by the centers and supported by the program offices which did not make the OMB submissions."

Mr. **Boland**. But it wasn't supported by NASA, either, because NASA didn't submit it to OMB, did it?

General **McGarvey**. No, sir. That is correct.

But in answer to your question, it was a project that the center had submitted last year, the program offices and ourselves did not support it. That is why it doesn't appear in this list.

The point I am making is that this is not the first time the project has come up as a requirement.

Mr. **Boland**. Any reason why it was not supported?

General **McGarvey**. Because of other, higher priorities.

CONSTRUCTION OF SPACECRAFT SYSTEMS DEVELOPMENT FACILITY

Mr. **Boland**. On page CF4-2, there is an $8 million request for construction of spacecraft systems development and integration facility. This is the same request that was denied in last year's appropriation bill and which should total approximately $16 million.

What is the actual impact of this request in that the payloads that are discussed in the justification as rationale for building the facility are also being slipped?

General **McGarvey**. Yes, sir. This is the——

Mr. **Boland**. And do the payloads determine whether or not this facility is essential?

Is it yes or no?

Dr. **Fletcher**. Dr. Edelson?

Mr. **Boland**. Did you get the question?

Dr. **Edelson**. But I am not sure whether the yes or no answer is appropriate.

This is a facility needed by the Goddard Space Flight Center to handle certain classes of payloads.

Those payloads involve the Hubble Space Telescope, Gamma Ray Observatory, UARS, and the Cosmic Background Explorer (COBE).

Mr. **Boland**. Well, whether or not the payloads that are talked about in this justification, whether or not those payloads are being slipped, is that—

Dr. **Edelson**. The development work on these payloads is not being slipped significantly.

We are working on those payloads right now and the launch date for them will slip, but the need to have a facility of that class does not slip with the launch date of individual payloads.

KSC—CONSTRUCTION OF OPF ANNEX

Mr. **Boland**. Okay.

On CF3-2, the JFK Space Center, you are requesting $3,400,000 for the construction of an addition to the Orbiter Processing Facility Annex. You indicate that this project eliminates existing trailers north and west of the annex now used by personnel involved in orbiter processing.

Could this be delayed for at least a year in view of the fact that there will be no orbiter processing for sometime?

General **McGarvey**. It could be delayed, Mr. Chairman, but this is the fourth time that we have attempted to provide this facility.

Mr. **Boland**. I know, but now you are asking for it at a time when it appears as if you don't need it.

Am I right or wrong on this? What sort of orbiter processing are you going to be accomplishing?

General McGarvey. Let's put it in perspective, Mr. Chairman. If it is funded in this budget the construction would be initiated in January 1987. It is about a 12-month construction period so the facility will not be completed until December of 1987. If we start flying again in July, 1987 we certainly will be back to processing two orbiters in the two high bays, and we need the facility to eliminate the trailers.

Mr. Boland. I suppose that when you make a recommendation to build a facility you look at what the flight rate will be, is that correct?

General McGarvey. Yes, sir.

Mr. Boland. Do you believe you will be flying at that rate, 24 in that period of time?

General McGarvey. No, sir. I think——

Mr. Boland. Well, do you need this?

You recognize as well as we do that there has to be some give in this budget somewhere, and even if we can pick it up by nickel and diming in this budget, we have to do it.

As the late Senator Dirksen said, a million here and a million there suddenly becomes a billion.

Dr. Fletcher. I think Mr. Moser has a statement.

Mr. Moser. Currently, we have three orbiters which are being processed and updated down at the Cape right now. One is having to be done in the vertical assembly building. It is very limited what can be done there, only mechanical and thermal protection system work.

Our flight rate projection which we have reviewed with the Administrator and presented outside, assumes that we have this facility here so that we can, in fact, do more work and do it in a way to support a safe flight rate.

In my judgment, in addition to removing the trailers and all, it provides that kind of capability.

JPL—CONSTRUCTION OF ENGINEERING SUPPORT BUILDING

Mr. Boland. On CF5-2, you are requesting $9,800,000 for the construction of an engineering support building at the Jet Propulsion Laboratory. On page CF5-3 it states that the project will provide significant savings by moving out of leased space.

What are those savings per year?

General McGarvey. They are $1,239,000 per year in lease cost, plus related transportation.

You know, the leased space is eight miles from the center and there is a lot of transportation costs back and forth to the location.

The bulk of the savings, over one million, dollars is in the leases themselves.

Mr. Boland. So, at that rate, the pay-back will be less than eight years, won't it?

General McGarvey. In a simple pay-back, it will amortize itself in less than eight years.

ARC—CONSTRUCTION OF A HUMAN PERFORMANCE RESEARCH LABORATORY

Mr. **Boland**. On CF6-2, the Ames Research Center has a request for $9,400,000 for the construction of a human performance research laboratory.

Is this construction directly related to the space station?

General **McGarvey**. Yes, sir. In part, it supports both the space station development and the generic aeronautical human performance research carried on also at the Ames Research Center.

It pulls our people out of some dispersed locations and puts both the space activities and the aeronautical activities in one facility that would accommodate the total requirements.

Mr. **Boland**. Now last year, Bill, you indicated that this would cost $12.6 million. How did you manage to save almost $3 million in the last 12 months?

General **McGarvey**. We went through a very strenuous review of the requirements again and reduced both the aeronautical and space requirements. Space technology work requires the high bay area to the very minimum.

There was one area for rotorcraft which we did not include in the building. So, we have reduced the scope through a very strenuous scrub process at the center and with the program offices.

LARC—8-FOOT HIGH TEMPERATURE TUNNEL

Mr. **Boland**. On CF8-2, there is a $9,700,000 request for the eight-foot high temperature tunnel at the Langley Research Center.

As the justifications detailed on the following pages indicate, these modifications are in addition to the $13,800,000 which was intended to complete those modifications.

Can you describe for the Committee in a little more detail why this project was underestimated?

General **McGarvey**. Yes sir. In fiscal year 1985, the $13.8 million project was programmed to provide this capability which was for hypersonic air breathing propulsion research and aerothermal structural research, as a unique national test capability.

We did a preliminary engineering report and programmed it in at $13.8 million in 1985 which Congress appropriated.

As we entered the details of the final design of it and got about 40 percent into the design effort, it became very clear to us that we had grossly underestimated the complexity of the requirements and criteria for such a high energy facility. We set up some special review teams made up from the other centers and had some third party outside reviews of it, and determined that we had really underestimated the complexity of the tunnel and the costs associated with it.

That forced us to come back to you last year and advise you that we could not build it for $13.8 million. We would split the project into two separate projects and request additional money in this 1987 program to complete it to give us the total capability.

Mr. **Boland**. Where did the problem of the underestimating occur? Was it at the center at Langley or was it at Headquarters?

General McGarvey. My personal opinion is, I believe that it was at the Langley Research Center. I would let Dr. Colladay respond, if you would like to add to that, Ray.

Dr. Colladay. I would agree with that, General McGarvey; it was done in the preliminary design at Langley.

CONSTRUCTION OF A SECOND TDRSS FACILITY

Mr. Boland. Under the various locations you are requesting $22 million for the construction of a second Tracking and Data Relay Satellite System, TDRSS, ground terminal facility in New Mexico. Was this originally envisioned as a requirement for the tracking and data relay satellite system? Is that correct? It wasn't carried in your list submitted for the record last year; you didn't carry this one. When did this requirement develop?

Mr. Aller. The requirement developed over the past several years, actually. We have been looking at this type of facility for several years and studying and examining just what we wanted. It basically is a back-up to the present facility which is a single point failure. We could lose the entire system with some kind of catastrophic fire at the site. This is a program that would provide duplicate capability for two antenna systems at a second site near the present White Sands area.

Mr. Boland. As you have indicated, the justifications indicate that the rationale for this project is tied to the fact that the ground based space flight tracking and data network would be phased out in 1986.

Does the accident impact this at all?

Mr. Aller. No, sir, not in my opinion at all.

Mr. Boland. Why?

Mr. Aller. It is strictly a back-up to the present site that won't be on line as a system until 1991 or 1992.

That is when we will be able to use that facility and the systems that will be implemented there. The $22 million is in the 1987 budget for the facility itself.

Mr. Boland. Okay.

Mr. Aller. Not the equipment.

Mr. Boland. You state the accident really has not impacted this particular project then?

Mr. Aller. No, sir, it has not.

Mr. Boland. I take it you would not have requested this project if the shuttle flights were not anticipated before the last quarter of calendar 1987.

Mr. Aller. Yes, sir. We are presently supporting about five spacecrafts with that system.

It is not just a simultaneous support system. We are supporting LANDSAT 4 and 5, SMM, and SME. The system is active today. Our problem is by the early 1990's we want to assure that we have some kind of a back-up capability. Every communications satellite operator in the country has a back-up system.

Mr. Boland. Tell me, was the existing ground terminal constructed with facility funds, or was that constructed as part of the $2.9 billion TDRSS?

Mr. Aller. That was part of TDRSS.

It was not under our normal budgeting process. It was built by the contractor. And it was contracted for by our contractor.

DFRF—CONSTRUCTION OF AN INTEGRATED TEST FACILITY

Mr. **Boland**. With respect to the Dryden Flight Research Facility, reflected on CF7-2, you have a budget request of $17.5 for the construction of an integrated test facility. In the list which you submitted last year the cost of that facility was $14 million.

What has caused that 20 percent growth in the past 12 months?

General **McGarvey**. A better definition and refinement of the requirements is the principle reason, Mr. Chairman. We do not have a state-of-the-art integrated test facility. Aircraft technology has outstripped our facilities' capabilities for testing and qualification. As we looked into it and got into the completed preliminary engineering report, it became very clear to us that our estimate last year was too low. And we increased it to cover that cost.

Mr. **Boland**. Okay, Mr. Green. This is on construction of facilities.

Mr. **Green**. I have no questions.

Mr. **Boland**. Mr. Coughlin?

Mr. **Coughlin**. I have one brief question, and I am not sure if it overlaps, but you have facilities listed such as payload, control rooms, biomedical research, cargo hazardous servicing facilities. Are these all tied into the shuttle program?

General **McGarvey**. Those are categories of types of facilities, Mr. Coughlin, that we have put in the budget format for that purpose. The majority of those, take payload facilities, for example, are primarily for the shuttle itself, and they are in this year's budget. Looking at the summary sheets now, I don't believe we have any payload facilities, per se.

Mr. **Coughlin**. Thank you, Mr. Chairman.

BUDGET REQUEST FOR ACTS

Mr. **Boland**. Mr. Boner.

Mr. **Boner**. Thank you, Mr. Chairman.

NASA requested $119 million for the Advanced Communications Technology Satellite, ACTS, and the President requested no funds. The House Science and Technology Committee authorized $95 million for ACTS.

What program changes will be made at this level of funding?

Dr. **Fletcher**. Mr. Newman will have to answer that.

Let me just say that this is still a very high priority project for NASA to do and we think it ought to go ahead if there is enough money to do that. What we have to give up in order to do it, I guess, remains to be seen.

Mr. Newman.

Mr. **Newman**. Let's refer the question to Dr. Edelson.

Dr. **Edelson**. At the $119 million level we would launch in the fourth quarter of 1989, and at the $95 million level we are figuring a seven- to nine-month slip and that would be about the second quarter of 1990.

We believe we can do that so that the total project cost will stay within the estimate which is $325 to $425 million.

Mr. **Boner**. So, by reducing it to this level then, you are looking at a seven- to nine-month slip?

Dr. **Edelson**. Yes, sir.

Mr. **Boner**. And from when you thought it would originally be launched?

Dr. **Edelson**. Yes, sir.

COMMERCIALIZATION OF SPACE

Mr. **Boner**. One other question, if I may, Mr. Chairman.

Last year NASA made several awards establishing Centers for Commercialization of Space.

Each award is valued at about $5 million over a five-year period and Vanderbilt University was one of the ones that was selected.

My question is, with the reduction in funds, is the private funding level conditioned upon receiving Federal funds at a certain level, and if these institutions demonstrate their continued excellence, will NASA be in a position to continue the awards for five years at the levels originally contemplated when the awards were announced?

Dr. **Fletcher**. Mr. Gillam.

Mr. **Gillam**. Yes, sir, they will.

Our 1987 budget as proposed includes a continuation of the Centers that were selected.

Our subsequent budgets will also contain continued funding for those Centers and the 1987 budget contained additional amounts of funds for selection of new Centers.

Mr. **Boner**. Are the private funds now conditioned on any level of Federal funds?

Mr. **Gillam**. Not to our knowledge.

Mr. **Boner**. Thank you, Mr. Chairman.

Mr. **Boland**. Mr. Mollohan.

Mr. **Mollohan**. No questions, Mr. Chairman.

RESEARCH AND PROGRAM MANAGEMENT

Mr. **Boland**. That finishes Construction of Facilities. We will turn to Research and Program Management.

Mr. Green?

Mr. **Green**. The 1986 estimate was $1,341,534,000, reflecting sequestration of $58,566,000 and the proposed transfer of $38,100,000, included in the 1986 supplemental appropriation.

The 1987 request is $1.441 billion, and that reflects an increase of $99,466,000.

Full-time equivalent employment is requested at 22,061, essentially the same as in 1986.

I know that the Challenger accident has an effect on your 1987 R&PM request. Certain increases, like those associated with the increased launch rate, will not occur. It may also be that additional costs will occur to cover the cost of the Phillips study.

What effect will the Challenger accident have on the R&PM request for 1987?

Mr. **Newman**. In the summaries provided we are proposing to take $16 million out of the 1987 request and that relates largely to utilities and overtime and work that would have related to the conduct of missions.

Mr. GREEN. Will there be any areas of the 1987 R&PM request that need to be increased as a result of the accident?

Mr. NEWMAN. There will be shifting, obviously, of people and efforts to resolve the effects of the accident as opposed to operating the shuttle. We do expect to be able to handle those within the level of $1.425 billion.

IMPACT OF SHUTTLE ACCIDENT ON CIVIL SERVICE LEVELS

Mr. GREEN. Do you believe as a result of the Challenger accident there is a need for additional civil service personnel in NASA? If so, how many and in what areas?

Dr. FLETCHER. Mr. Green, I think that is a good question. We have not taken a look at what our needs are. But let me just give you some possible things.

We may want to tighten up our R&QA in-house effort. We transferred some of that effort as you know, over to the Defense Department. We of course have to have in the near term more intensive reviews of all of our procedures. That is going to take outside help, as you have mentioned, the General Philips Committee, but there are other committees we are setting up to review the seals and other aspects of the shuttle program.

I think at this point we are not in a position to request any additional funds even though we may have to rejuggle to accommodate some of these needs that we are estimating. We have not pinned it down yet.

Do you want to add anything to that?

Mr. MOSER. No, sir.

Mr. GREEN. I gather that as a result of declines in Headquarters management levels, many of the science programs only have a single manager and essentially they use detailees from NASA Centers to help out with administration of the programs.

Given some of the contracting problems that NASA seems to have, do you contemplate a change in that to try to beef up the contract administration?

Dr. FLETCHER. Mr. Green, we are going to beef up everything at NASA and that is one aspect of things that we are beefing up. We would do that anyway despite all this negative publicity. We are down for 18 months and this is the time to take another look at the whole agency and decide how well we are doing and improve areas where we find weaknesses. But part of it is simply improving our management techniques from where we were. This is a chance which we don't get very often and so we are going to take it.

Mr. GREEN. Do you think there is a need to bring in-house work that is currently being done by contractors?

Dr. FLETCHER. At this point I don't anticipate anything of that sort. I would, however, accept the recommendations of General Philips and his staff if he sees any need for that.

I don't at this point see a need for it.

BUDGET AMENDMENT FOR R&PM

Mr. **Green**. Do you anticipate submitting a budget amendment for the 1987 R&PM request? If so, when?

Dr. **Fletcher**. I don't anticipate any, but again we will have to see how it plays out. I guess the real question is can we absorb increases in what we have already presented to you. We are guessing at this point, of course.

Mr. **Newman**. Except as we mentioned the adjustment of about $16 million.

Dr. **Fletcher**. That was——

Mr. **Newman**. Mr. Boland mentioned that yesterday.

BUDGET REDUCTIONS IN R&PM

Mr. **Green**. When one goes through the 1986 numbers with the sequestration and supplemental, your R&PM appropriation is $20,466,000 less than shown in the 1986 column of the justifications on page 4. From which areas of the 1986 current estimates, as shown in the justifications, do you propose to take that reduction?

Mr. **Newman**. Of the $20 million reduction, actually $20.5 million, about $7.2 would be from personnel and related costs, due to the impact of the hiring freeze that we have had on the agency for most of this year, and a reduction in training this year. There is a reduction in travel of $200,000, and $13.1 million would be from the operation of installations.

Mr. **Green**. From which program will you transfer the $24 million in R&D and $14.1 million in Space Flight Control and Data Communications?

Mr. **Newman**. I would have to go back to the operating plan because we did that as a whole unit. We did detail that in the operating plan.

Mr. **Green**. If you can supply it for the record then.

Mr. **Newman**. All right.

[The information follows:]

By direction of the President, the amounts sequestered in compliance with Gramm-Rudman-Hollings were derived arithmetically by applying a 4.3 percent reduction equally to each program, project and activity. A revised FY 1986 Operating Plan was submitted to Congress on March 24, 1986, which redistributed the total Gramm-Rudman-Hollings reduction in a balanced manner, taking space and aeronautics program considerations into account, and incorporated the funding increases and offsetting reductions which resulted from the Challenger accident. This plan assumed Congressional approval of authority to transfer $24.0 million from Research and Development and $14.1 million of Space Flight, Control and Data Communications funds to Research and Program Managements. The source to those funds is detailed below:

Research and development	−24.0
Space station	−.9
Space transportation and capability development	−14.3
Physics and astronomy	−11.7
Life sciences	−.8
Planetary exploration	16.0
Space applications	−8.9
Technology utilization	—
Commercial use of space	−.1
Aero research and technology	−1.5
Space research and technology	−1.8
Tracking and data advanced systems	—

Space flight control and data communications	−14.1
Shuttle production and ops capability	13.7
Space transportation ops	−10.6
Space and ground network, communications and data systems	−17.2
Research and program management	38.1
Total	—

Mr. GREEN. What if the transfer does not occur? Which R&PM areas would be reduced? Again, you can supply it for the record.

[The information follows:]

If the requested transfer of $38.1 million to R&PM from R&D and SFCDC were not approved this fiscal year, NASA would be compelled to furlough all its Civil Service workforce for about 10 days. In addition, a similar action relating to the employees of the support service contracts paid from R&PM would be taken.

Mr. NEWMAN. Let me say that if we are not able to make that transfer it is clear that we would have to impact the personnel and related area. It would put us in a terrible situation.

Mr. GREEN. Would you be able to support the 22,061 workyears in 1986 with $1,341,534,000? If not, how many workyears can be supported with that amount of funding?

Mr. NEWMAN. The 1987 figures——

Mr. GREEN. That is with the transfer and minus the sequestration.

Mr. NEWMAN. We expect to run about 120 to 150 FTE's under in order to comply with the availability of funding.

Mr. GREEN. How many employees are currently on-board?

Mr. NEWMAN. Currently, the program is 20,887 plus there are about 900 temporaries.

Mr. GREEN. For the record, would you let us know how you currently stand against your obligational plan for personnel compensation and benefits?

Mr. NEWMAN. Through April, obligations are slightly above a straight line rate for the number of workdays to in FY 1986.

[The information follows:]

Through the month of May, we have obligated $643,823,000 of the Personnel and Related Cost plan or 66.9 percent of plan. Since the annual straight line projection, based on the number of work days so far in FY 1986, is 66.7 percent, we are obligating just slightly higher (.2 percent) than the straight line plan.

COST OF ROGERS COMMISSION

Mr. GREEN. Is it correct that the Rogers Commission costs will be charged to the 1986 R&PM appropriation?

Mr. NEWMAN. In support of the Rogers Commission we are incurring about $2.2 million in costs, of which about $1.4 million is for special support to them and will be out of SFCDC and the rest out of R&PM.

Mr. GREEN. How does that break down by object classification—for the record?

Mr. NEWMAN. Yes

[The information follows:]

In support of the Rogers Commission through May 23, 1986, NASA has incurred $2.2 million in costs. About $1.4 million will be out of SFC&DC for special support. The rest is out of R&PM. A detailed breakdown by object classification follows.

PRESIDENTIAL COMMISSION ON THE SPACE SHUTTLE CHALLENGER ACCIDENT

[Costs as of May 23, 1986]

	Object class	Cost	Description
R&PM:			
Personnel and related costs	11	$43,600	Compensation—reimbursable detailees (Alton Keel, OMB; Martha Black, OMB; Johnathon Thompson, action).
		12,500	Compensation—consultant (Ronald Waite).
		29,400	Overtime compensation for seven Hqtrs. employees.
		85,600	
Travel	21	170,900	
Operation of installation	22	1,000	Air Express.
	23	58,600	Word processor equipment and software rental.
	24	7,500	Printing and reproduction.
	25	542,600	A/V taping; editorial, writing, transcription, art services; secretarial and word processing support.
	26	6,800	Electronic materials.
	31	26,400	EDP equipment purchases.
		642,900	
Total R&PM costs		899,400	
SFCDC	25	1,400,000	Justice Department Civil Division contract support for document collection, control, and retrieval.

COST OF THE PHILLIPS STUDY

Mr. GREEN. In connection with the Phillips Study, what do you estimate will be the total R&PM cost of Phillips?

Dr. FLETCHER. We haven't put that whole team together. We don't anticipate that there will be a large number of people. In fact a good many of them will be part time. They will be consultants brought in from the outside. The maximum number should not be more than about 20 people because they expect to rely on internal people within NASA for most of the studies that they will make so we can make an estimate of that for the record if you would like.

Mr. GREEN. Just tell us what the extra cost is above and beyond your own people.

[The information follows:]

NASA has arranged for the Phillips study to be conducted with the support of the National Academy of Public Administration. General Phillips has been out of town and will be holding his first organization and planning discussions with Academy officials during the week of June 2–6. Until he develops the specific support he will require, estimate of the costs cannot be made. We will forward the estimates to you as soon as they are prepared. At this time, it is expected that they will consist of study team and short-term consultant compensation and travel and Academy expenses for support.

Mr. GREEN. Will there be any 1987 R&PM costs for that?

Dr. FLETCHER. I expect there will be, Mr. Green, but also a very small amount because we are just forming the group now and its principal focus is dealing with the Space Station management.

So they have not focused on the longer term. We are hopeful that we can finish that review by the end of this calendar year, but that would take some fiscal year 1987 money.

Mr. **Green**. If you could for the record, give us an estimate of what you anticipate for 1987.

[The information follows:]

As indicated in our response to page 48, we have not yet been informed of the study support requirements.

SAVINGS FROM REDUCED STS LAUNCHES

Mr. **Green**. What do you estimate will be the 1986 R&PM savings from not launching ten additional launches that were scheduled for 1986?

Dr. **Fletcher**. Mr. Newman will have to answer that.

Mr. **Newman**. We think the 1986 requirements will not be significantly affected. We have already taken a number of reductions and we don't see how we can reduce below the figures that we have already in the R&PM account.

Dr. **Graham**. I might add to that, Mr. Green, much of the manpower that would have been used in the higher level functions in the launch operations have been diverted to support our review and analysis of data from the accident and not to support the space flights. So there has been redirection of the manpower there but we don't see reductions.

Mr. **Green**. For the record, could you please update the table on page SUM-4 reflecting the total of $1,341,534,000 in 1986 and $1,425,000,000 in 1987.

Mr. **Newman**. We can provide you some of those numbers right now if you prefer.

Dr. **Fletcher**. Let's do it for the record.

[The information follows:]

A revised page SUM-4 from the Budget Estimates, Fiscal Year 1987, Volume III, Research and Program Management, follows.

SUMMARY OF THE BUDGET PLAN BY FUNCTION

[Thousands of dollars]

	1985 actual	1986 column of budget estimate	1987 current estimate	GRH estimate	1987 column of the 1987 budget	Revised fiscal year 1987 budget
I Personnel and related costs	954,592	[1] 973,813	969,104	961,900	980,865	979,865
II Travel	29,704		31,000	31,000	30,800	33,700
III Operation of installation	347,484	382,188	361,896	348,800	426,435	411,435
A. Facilities services	(176,808)	(212,273)	(199,150)	(191,800)	[2] (231,694)	(222,435)
B. Technical services	(60,652)	(66,071)	(65,838)	(62,000)	[3] (86,380)	(84,000)
C. Management and operations.	(110,024)	(103,844)	(96,908)	(95,000)	(108,361)	(105,000)
Total	1,331,780	[1] 1,387,001	1,362,000	1,341,500	1,441,000	1,425,000

[1] Adjusted to include $42,000 to cover costs of the pay freeze versus originally proposed in fiscal year 1986.

[2] Includes $5,000 for hazardous substances release assessments.

[3] Includes $7,000 for the agencywide Automated Systems Development Program.

GAO REPORT ON A-76 PROCESS

Mr. **Green**. Turn to the GAO report of November 1985 entitled "Contracting Out—NASA Not Complying with OMB Circular A-76."

In the report the GAO reviewed contract files at the Lewis Research Center and determined that NASA had not complied with the procedural aspects of Circular A–76 which requires cost comparisons before contracting out in-house functions.

We have discussed the question of civil service versus contractor workyears over the years. I guess there is concern here that because of personnel ceilings, NASA resorts to contracts for services that were previously done in-house—even though that might wind up costing the taxpayer more for a particular service.

Why shouldn't the cost be determined when deciding whether or not to contract out for a service previously done in-house?

Dr. Fletcher. I can answer generally on that, Mr. Green, but I would like to ask Mr. Nysmith to follow up on the specific instance.

Generally speaking we do not contract out for things that are properly the responsibility of civil servants. As you recall, over the years this has been a continuing difficulty because of the legal interpretation of what that means. I remember very distinctly a case that went on in Judge Wadde's court I think for ten years trying to decide how to operate with support contractors. I think the outcome of that was that we have tightened up our rules on how we deal with the contractors and how we deal with civil servants.

That was a long time ago. What has happened since then, Mr. Nysmith?

Mr. Nysmith. You know, NASA contracts out today about 85 percent of the work in any case, and we have had a running dialogue with the OMB and GAO on application of A–76. The concept we have always followed has been that the cost is one consideration, a very important one, but it is not the only one. We look at mission suitability and overall effectiveness when we decide to contract out. The A-76 process requires a very complex, I will even say adversarial, study. You have to set up in-house and evaluate the way you do business which is fine, but you then have to actually have several contractors set in place and compete those two together.

By the time you finish, it typically takes two to three years, then you make a decision based solely on cost. What we tend to do is find out the cost of doing business, then we informally find out the cost of contracting out. We let the Center Directors for the most part decide what they need to do in-house and what they really should do out of house.

We have no debate with the GAO or OMB on whether or not we are contracting out work that is better done by the private sector. They agree that we are. What our debate with them is, that we are not following the ritualistic mechanical process of doing it in a cost-benefit study way which takes two to three years. We decide on the mission suitability to contract out and we contract out. We did determine the cost but not to the satisfaction of the GAO.

Mr. Green. You are saying, then, that the OMB personnel ceiling is not a significant factor in terms of decisions of whether to contract out?

Mr. Nysmith. No, in fact this year we have agreed with the OMB that we will do some additional contracting out in some areas, and they are agreed that any positions that we free up we can reapply to other activities.

Mr. **Green**. Would your policy change if you didn't have ceilings on the number of civil service employees you had?

Mr. **Nysmith**. I don't think so, because the process we are using is really what is required to do the job to the best and most efficient way.

NASA'S RESPONSE TO THE GAO REPORT

Mr. **Green**. In your January 27, 1986 response to the GAO report, you indicated, and I quote, "NASA will develop the necessary policy statement and implementing actions to require that all contracting out decisions have a documented cost evaluation process along with an analysis of all other considerations used in the decision-making process."

Has that policy statement been developed?

Mr. **Nysmith**. No, it is under development right now. It is not out yet.

Mr. **Green**. When do you expect to have it out?

Mr. **Nysmith**. This summer.

Mr. **Green**. Have you begun some process of documenting the decisions yet?

Mr. **Nysmith**. We are working in a particular case that the GAO was involved with at Lewis. We are working with Lewis to develop the paperwork to document the process that they used. So we are specifically working that case.

SUPPORT SERVICE CONTRACTORS

Mr. **Green**. The number of workyears for NASA in 1987 is 22,061 which is the same as in 1986. Information from NASA shows that support service contractors funded from the R&PM account increases from 4,235 in 1986 to 4,416 in 1987. Why does the number of support service contractors funded from R&PM increase by 181 in 1987?

Mr. **Newman**. Some of that was to support the shuttle launch rate; part of the reduction of the $16 million that I spoke of would be taken in that area.

Mr. **Green**. Okay.

Mr. **Newman**. So I believe those are no longer applicable.

Mr. **Tulip**. There will be some changes at other centers to cover needed increases in support that we found in selected administrative areas.

Mr. **Green**. What areas are those?

Mr. **Tulip**. Largely in ADP and in the maintenance area.

Mr. **Green**. Why is that work done by contractors rather than by civil servants?

Mr. **Tulip**. Generally it is things we already contract for, such as maintenance, operation of our computers and so forth.

Mr. **Green**. What is the cost of the increased support service contracts in 1987?

Mr. **Tulip**. About $6 million, sir.

Mr. **Newman**. Was that as budgeted, before the adjustment?

Mr. **Tulip**. Yes.

Mr. Green. For the record, could you update the table that begins on page 203 of last year's hearings on civil service and contractor populations?

[The information follows:]

FY 1987 ESTIMATES 11-Jun-86

CENTER: DRYDEN

	FY 1985	FY 1986	FY 1987
POPULATION	862	851	851
CIVIL SERVICE	480	480	480
NASA	479	479	479
OTHER AGENCIES	1	1	1
CONTRACTORS	306	303	303
PRIME & MISC.	18	14	14
SUPPORT	288	289	289
TENANTS AND OTHERS	76	68	68
BUDGET AUTHORITY ($M)	54.5	61.4	67.5
SFCDC	10.9	16.1	15.9
R&D	19.9	20.2	25.7
R&PM	23.0	23.5	24.3
C of F*	0.7	1.6	1.6

* - PLUS MINOR PROGRAMS

FY 1987 ESTIMATES 11-Jun-86

CENTER:_PLUMBROOK

	FY 1985	FY 1986	FY 1987
POPULATION	202	88	48
CIVIL SERVICE	18	18	18
NASA	6	6	6
OTHER AGENCIES	12	12	12
CONTRACTORS	39	34	30
PRIME & MISC.	0	0	0
SUPPORT**	39	34	30
TENANTS AND OTHERS	145	36	0
BUDGET AUTHORITY ($M)	2.5	2.1	2.1
SFCDC	0.0	0.0	0.0
R&D	0.0	0.0	0.0
R&PM	2.5	2.1	2.1
C of F*	0.0	0.0	0.0

* - PLUS MINOR PROGRAMS
** - INCLUDES REIMBURSABLE

FY 1987 ESTIMATES 03-May-86

CENTER: ___NASA___

	FY 1985	FY 1986	FY 1987
POPULATION	68,393	69,352	68,796
CIVIL SERVICE	26,341	26,325	26,370
NASA	22,185	22,050	22,072
OTHER AGENCIES	4,156	4,275	4,298
CONTRACTORS	37,428	38,239	37,678
PRIME & MISC.	10,430	10,271	9,791
SUPPORT	26,998	27,968	27,887
TENANTS AND OTHERS	4,624	4,788	4,748
BUDGET AUTHORITY ($M)	7,013.9	7,046.8	7,019.0
SFCDC	3,483.1	3,275.4	2,939.3
R&D	2,079.4	2,307.4	2,518.5
R&PM	1,331.8	1,362.0	1,428.3
C of F	119.6	102.0	132.9

FY 1987 ESTIMATES 01-May-86

CENTER: JSC

	FY 1985	FY 1986	FY 1987
POPULATION	12,283	13,004	13,342
CIVIL SERVICE	3,754	3,726	3,746
NASA	3,420	3,388	3,407
OTHER AGENCIES	334	338	339
CONTRACTORS	8,340	9,089	9,407
PRIME & MISC.	1,481	1,481	1,481
SUPPORT	6,859	7,608	7,926
TENANTS AND OTHERS	189	189	189
BUDGET AUTHORITY ($M)	1617.3	1410.1	1132.2
SFCDC	1159.6	918.9	560.5
R&D	239.7	280.1	339.6
R&PM	214.8	210.0	218.1
C of F*	3.2	1.1	14.0

* - PLUS MINOR PROGRAMS

FN:JSCQAPOP

FY 1987 ESTIMATES 03-May-86

CENTER: ELLINGTON AFB

	FY 1985	FY 1986	FY 1987
POPULATION	297	311	311
CIVIL SERVICE	76	76	76
NASA	76	76	76
OTHER AGENCIES	0	0	0
CONTRACTORS	221	235	235
PRIME & MISC.	0	0	0
SUPPORT	221	235	235
TENANTS AND OTHERS	0	0	0
BUDGET AUTHORITY ($M)	41.3	41.4	37.7
SFCDC	35.4	34.8	31.0
R&D	0.9	1.6	1.7
R&PM	4.5	4.6	4.5
C of F*	0.5	0.4	0.5

* - PLUS MINOR PROGRAMS

FN: EAFBQAPOP

FY 1987 ESTIMATES 03-May-86

CENTER: WHITE SANDS

	FY 1985	FY 1986	FY 1987
POPULATION	983	1,013	1,091
CIVIL SERVICE	71	74	76
NASA	56	55	55
OTHER AGENCIES	15	19	21
CONTRACTORS	399	384	385
PRIME & MISC.	0	0	0
SUPPORT	399	384	385
TENANTS AND OTHERS	513	555	630
BUDGET AUTHORITY ($M)	27.5	24.4	29.2
SFCDC	11.3	8.4	9.6
R&D	10.3	10.9	13.7
R&PM	5.7	5.1	5.6
C of F*	0.2	0.0	0.3

* - PLUS MINOR PROGRAMS

FN:WSQAPOP

FY 1987 ESTIMATES 01-May-86

CENTER:____KSC

	FY 1985	FY 1986	FY 1987
POPULATION	14,048	14,243	13,937
CIVIL SERVICE	2,377	2,341	2,346
NASA	2,153	2,117	2,112
OTHER AGENCIES	224	224	234
CONTRACTORS	9,575	9,629	9,341
PRIME & MISC.	1,062	1,026	826
SUPPORT	8,513	8,603	8,515
TENANTS AND OTHERS	2,096	2,273	2,250
BUDGET AUTHORITY ($M)	650.2	692.8	760.5
SFCDC	383.1	407.2	485.8
R&D	45.7	69.9	63.2
R&PM	184.5	194.7	208.1
C of F*	36.9	21.0	3.4

* - PLUS MINOR PROGRAMS

FN:KSCQAPOP

FY 1987 ESTIMATES 03-May-86

CENTER: _ _MSFC

	FY 1985	FY 1986	FY 1987
POPULATION	12,916	12,834	12,564
CIVIL SERVICE	4,757	4,805	4,813
NASA	3,385	3,358	3,363
OTHER AGENCIES	1,372	1,447	1,450
CONTRACTORS	7,995	7,866	7,590
PRIME & MISC.	6,974	6,913	6,649
SUPPORT	1,021	953	941
TENANTS AND OTHERS	164	163	161
BUDGET AUTHORITY ($M)	1,923.0	1,951.0	1,811.5
SFCDC	1,223.5	1,258.2	1,087.7
R&D	499.8	486.2	517.9
R&PM	198.1	200.1	203.8
C of F*	1.6	6.5	2.1

* - PLUS MINOR PROGRAMS

FN:MSFCQAPOP

FY 1987 ESTIMATES 03-May-86

CENTER: MICHOUD ASSEMBLY FACILITY (MAF)

	FY 1985	FY 1986	FY 1987
POPULATION	6,171	6,444	6,347
CIVIL SERVICE	1,377	1,451	1,454
NASA	17	17	17
OTHER AGENCIES	1,360	1,434	1,437
CONTRACTORS	4,745	4,945	4,845
PRIME & MISC.	4,745	4,945	4,845
SUPPORT	0	0	0
TENANTS AND OTHERS	49	48	48
BUDGET AUTHORITY ($M)	405.5	419.5	433.1
SFCDC	401.3	416.2	430.0
R&D	0.0	0.0	0.0
R&PM	0.7	0.7	0.7
C of F*	3.5	2.6	2.4

* - PLUS MINOR PROGRAMS

FN:MAFQAPOP

FY 1987 ESTIMATES 03-May-86

CENTER: SLIDELL COMPUTER COMPLEX

	FY 1985	FY 1986	FY 1987
POPULATION	284	288	286
CIVIL SERVICE	7	7	7
NASA	7	7	7
OTHER AGENCIES	0	0	0
CONTRACTORS	261	265	265
PRIME & MISC.	143	143	143
SUPPORT	118	122	122
TENANTS AND OTHERS	16	16	14
BUDGET AUTHORITY ($M)	12.8	14.7	15.0
SFCDC	12.5	14.4	14.7
R&D	0.0	0.0	0.0
R&PM	0.3	0.3	0.3
C of F*	0.0	0.0	0.0

* - PLUS MINOR PROGRAMS

FN:SCCQAPOP

FY 1987 ESTIMATES 03-May-86

CENTER: NSTL

	FY 1985	FY 1986	FY 1987
POPULATION	4,546	4,543	4,554
CIVIL SERVICE	1,779	1,793	1,802
NASA	130	134	134
OTHER AGENCIES	1,649	1,659	1,668
CONTRACTORS	1,481	1,460	1,457
PRIME & MISC.	527	455	446
SUPPORT	954	1,005	1,011
TENANTS AND OTHERS	1,286	1,290	1,295
BUDGET AUTHORITY ($M)	31.1	33.2	32.2
SFCDC	6.3	8.3	8.6
R&D	10.8	11.5	12.2
R&PM	10.7	10.9	11.4
C of F*	3.3	2.5	0.0

* - PLUS MINOR PROGRAMS

FN:NSTLQAPOP

FY 1987 ESTIMATES 03-May-86

CENTER:_ARC TOTAL_

	FY 1985	FY 1986	FY 1987
POPULATION	4,080	4,109	4,154
CIVIL SERVICE	2,447	2,436	2,436
NASA	2,205	2,192	2,192
OTHER AGENCIES	242	244	244
CONTRACTORS	1,633	1,673	1,718
PRIME & MISC.	176	174	176
SUPPORT	1,457	1,499	1,542
TENANTS AND OTHERS	0	0	0
BUDGET AUTHORITY ($M)	363.5	388.2	443.3
SFCDC	12.3	15.8	14.8
R&D	217.3	239.5	267.7
R&PM	120.3	124.7	133.9
C of F*	13.6	8.2	26.9

* - PLUS MINOR PROGRAMS

FY 1987 ESTIMATES 03-May-86

CENTER: LARC

	FY 1985	FY 1986	FY 1987
POPULATION	4,824	4,862	4,909
CIVIL SERVICE	3,108	3,094	3,094
NASA	2,959	2,945	2,945
OTHER AGENCIES	149	149	149
CONTRACTORS	1,459	1,511	1,558
PRIME & MISC.	72	67	64
SUPPORT	1,387	1,444	1,494
TENANTS AND OTHERS	257	257	257
BUDGET AUTHORITY ($M)	337.0	332.9	388.5
SFCDC	0.1	0.1	0.1
R&D	176.0	177.9	221.7
R&PM	147.1	150.0	155.0
C of F*	13.8	4.9	11.7

* - PLUS MINOR PROGRAMS

FN:LARCQAPOP

FY 1987 ESTIMATES 03-May-86

CENTER:_LERC TOTAL

	FY 1985	FY 1986	FY 1987
POPULATION	3,904	3,953	3,974
CIVIL SERVICE	2,826	2,818	2,821
NASA	2,732	2,724	2,727
OTHER AGENCIES	94	94	94
CONTRACTORS	991	1,064	1,102
PRIME & MISC.	71	71	71
SUPPORT	920	993	1,031
TENANTS AND OTHERS	87	71	51
BUDGET AUTHORITY ($M)	452.2	469.0	358.1
SFCDC	3.4	3.0	0.5
R&D	311.4	323.0	201.5
R&PM	137.4	143.0	150.3
C of F*	0.0	0.0	5.8

* - PLUS MINOR PROGRAMS

FY 1987 ESTIMATES 03-May-86

CENTER:_GSFC TOTAL_

	FY 1985	FY 1986	FY 1987
POPULATION	10,031	10,014	9,530
CIVIL SERVICE	3,741	3,757	3,757
NASA	3,690	3,706	3,706
OTHER AGENCIES	51	51	51
CONTRACTORS	5,747	5,714	5,230
PRIME & MISC.	67	84	78
SUPPORT	5,680	5,630	5,152
TENANTS AND OTHERS	543	543	543
BUDGET AUTHORITY ($M)	1,029.1	1,025.1	1,060.4
SFCDC	431.1	366.6	378.4
R&D	399.0	450.8	459.7
R&PM	196.8	203.9	214.3
C of F*	2.2	3.8	8.0

* - PLUS MINOR PROGRAMS

FY 1987 ESTIMATES 03-May-86

CENTER:_WALLOPS_

	FY 1985	FY 1986	FY 1987
POPULATION	951	976	980
CIVIL SERVICE	365	365	365
NASA	365	365	365
OTHER AGENCIES	0	0	0
CONTRACTORS	508	532	536
PRIME & MISC.	368	393	396
SUPPORT	140	139	140
TENANTS AND OTHERS	78	79	79
BUDGET AUTHORITY ($M)	77.2	76.4	69.2
SFCDC	10.8	14.4	15.1
R&D	37.8	33.9	26.2
R&PM	23.7	23.0	24.0
C of F*	4.9	5.1	3.9

* - PLUS MINOR PROGRAMS

FN:WALQAPOP

FY 1987 ESTIMATES 03-May-86

CENTER: ___HQS_____

	FY 1985	FY 1986	FY 1987
POPULATION	1,761	1,790	1,832
CIVIL SERVICE	1,552	1,555	1,555
NASA	1,511	1,486	1,486
OTHER AGENCIES	41	69	69
CONTRACTORS	207	233	275
PRIME & MISC.	0	0	0
SUPPORT	207	233	275
TENANTS AND OTHERS	2	2	2
BUDGET AUTHORITY ($M)	610.5	744.5	1,032.3
SFCDC	263.7	297.3	402.9
R&D	179.7	268.5	435.0
R&PM	122.1	124.7	133.4
C of F*	45.0	54.0	61.0

* - PLUS MINOR PROGRAMS

FN:HQSQAPOP

Mr. GREEN. Maybe we better go vote.

[Recess.]

Mr. GREEN. If we may resume.

Let's review the obligations by function. We will place a detailed Functional Data Summary Table provided by NASA in the record at this point.

[The information follows:]

11-Feb-86

6

TS_87
R&PM SUMMARY

RESEARCH AND PROGRAM MANAGEMENT
FY 1987 CONGRESSIONAL BUDGET
ANALYSIS OF OBJECT CLASS BY SUBFUNCTION
($K)

FY 85 ACTUAL OBS
IN 87 CONGRESSIONAL

Function	OC 11 Comp	OC 12 Bene	OC 13 Form Per	OC 21 Tvl	OC 22 Trans	OC 23 R/C/U	OC 24 Prt&Rep	OC 25 Oth Svc	OC 26 Sup&Mat	OC 31 Equip	OC 32 Lds&ST	OC 41-2 G,Con,In	Total
Pers. Compensation	843,009	0	0	0	0	0	0	0	0	0	0	0	843,009
Full-Time Perm Pos.	805,680												805,680
Pos. Other than Perm	16,255												16,255
Reimb. Detailees	4,895												4,895
Ot & Other Comp.	16,179												16,179
Benefits	0	97,487	315	0	0	0	0	0	0	0	0	0	97,802
CS Retirement		56,222											56,222
Fed Grp Life Ins		2,000											2,000
Fed Empl Health Ben		22,467											22,467
Workmen's Comp		5,268											5,268
FICA		2,252											2,252
Medicare		9,262											9,262
Other		16	0										16
Former Personnel		0	315										315
Supporting Cost	0	2,476	0	0	1,306	0	0	9,999	0	0	0	0	13,781
Transfer of Pers.	0	2,476	0	0	1,306	0	0	0	0	0	0	0	3,782
(PCS Benefits)		2,476											2,476
(Household Goods)					1,306								1,306
OPM Svcs (HQs only)								735					735
Training		0						9,264					9,264
PERS & RELATED COSTS	843,009	99,963	315	0	1,306	0	0	9,999	0	0	0	0	954,592
Prog. Travel				22,193									22,193
Scient & Tech				2,943									2,943
Mgmt & Operations	0	0	0	4,568	0	0	0	0	0	0	0	0	4,568
NASA non-local				3,727									3,727
Local & Invitat.				841									841
TRAVEL	0	0	0	29,704	0	0	0	0	0	0	0	0	29,704
Facilities Services	0	0	0	0	3	80,146	0	90,436	4,919	445	859	0	176,800
Rent of Real Prop						8,863							8,863
Maint & Related	0	0	0	0	1	0	0	33,364	1,950	382	640	0	36,345
Facilities					1	0		32,629	1,950	338	640		35,566
Equipment								735		44			779
Custodial						1		45,247	348	50	219		45,865
Utilities					2	71,274		11,825	2,621	13			85,735
Technical Services	0	0	0	0	16	1,261	405	49,244	2,251	7,306	0	109	60,592
ADP	0	0	0	0	0	1,072	15	34,569	768	6,159	0	0	42,583
Equipment						738		1,522	0	5,589			7,849
Operations						334	15	33,047	768	570			34,734
Scient & Tech Info	0	0	0	0	16	179	390	8,965	823	340	0	109	10,822
Library							0	2,015	612				2,627
Educ & Info					16	179	390	6,950	211	340		109	8,195
Shop Support Svcs						10		5,710	660	807			7,187
Mgmt & Operations	0	0	0	1,638	1,437	27,656	2,600	63,802	8,483	3,789	0	619	110,024
Admin Communicat.						24,156		4,021	137	4			28,318
Printing & Reprod				0		43	2,562	514	214	2			3,335
Transportation				1,638	1,419	2	0	13,128	1,004	240			18,422
Install Common	0	0	0	0	18	3,463	36	46,127	6,148	3,534	0	619	59,949
Ctr Mgmt & Staff					12	171	36	11,553	898	333		370	13,387
Medical Services					1	4		10,398	137	503			11,043
Install Supt Svcs					5	3,290		24,176	5,121	2,678		249	35,519
								0					
TOTAL OPER OF INSTAL	0	0	0	1,638	1,456	109,063	3,005	203,482	15,653	11,600	859	728	347,404
				132									132
TOTAL R&PM	843,009	99,963	315	31,342	2,762	109,063	3,005	213,481	15,653	11,600	859	728	1,331,700

FILE NAME: T6_87MAR
SUMMARY 2/26/87
FY 1986

RESEARCH & PROGRAM MANAGEMENT
FY 1987 CONGRESSIONAL BUDGET
OBJECT CLASS by SUBFUNCTION
($K)

Function	OC 11 Comp	OC 12 Bene	OC 13 Form Per	OC 21 Tvl	OC 22 Trans	OC 23 R/C/U	OC 24 Prt&Rep	OC 25 Oth Svc	OC 26 Sup&Mat	OC 31 Equip	OC 32 Lds&ST	OC 41-2 B,Con,In	Total
Pers Compensation	855,219	0	0	0	0	0	0	0	0	0	0	0	855,219
Full-Time Perm Pos.	817,018												817,018
Pos. Other than Perm	15,516												15,516
Reimb. Detailees	5,431												5,431
OT & Other Comp.	17,254												17,254
Benefits	0	98,646	290	0	0	0	0	0	0	0	0	0	98,936
CS Retirement		55,925											55,925
Fed Grp Life Ins		2,038											2,038
Fed Empl Health Ben		22,025											22,025
Workmen's Comp		5,522											5,522
FICA		2,035											2,035
Medicare		9,490											9,490
Other		0	0										0
Former Personnel		11	290										301
Supporting Cost	0	2,226	0	0	1,475	0	0	11,248	0	0	0	0	14,949
Transfer of Pers.	0	2,226	0	0	1,475	0	0	0	0	0	0	0	3,701
(PCS Benefits)		2,226											2,226
(Household Goods)					1,475								1,475
O&M Svcs (HQs only)								911					911
Training								10,337					10,337
PERS & RELATED COSTS	855,219	100,872	290	0	1,475	0	0	11,248	0	0	0	0	969,104
Prog. Travel				23,986									23,986
Scient & Tech				2,964									2,964
Mgmt & Operations	0	0	0	4,050	0	0	0	0	0	0	0	0	4,050
Non-local				3,420									3,420
Local & Invitat.				630									630
TRAVEL	0	0	0	31,000	0	0	0	0	0	0	0	0	31,000
Facilities Services	0	0	0	0	0	95,607	0	98,450	4,188	830	75	0	199,150
Rent of Real Prop						8,831							8,831
Maint & Related	0	0	0	0	0	0	0	33,840	2,028	586	75	0	36,529
Facilities								33,098	2,028	504	75		35,705
Equipment								742		82			824
Custodial						7		50,746	432	215			51,400
Utilities						86,769		13,864	1,728	29			102,390
Technical Services	0	0	0	0	42	1,814	323	57,068	2,028	4,441	0	122	65,838
ADP	0	0	0	0	9	1,640	18	41,027	835	3,833	0	0	47,362
Equipment					9	1,140		2,076	7	3,217			6,449
Operations						500	18	38,951	828	616			40,913
Scient & Tech Info	0	0	0	0	33	174	305	9,892	851	344	0	122	11,721
Library							0	2,382	641				3,023
Educ & Info					33	174	305	7,510	210	344		122	8,698
Shop Support Svcs								6,149	342	264			6,755
Mgmt & Operations	0	0	0	1,043	961	25,766	2,725	54,613	8,458	2,308	0	234	96,108
Admin Common					10	20,948		3,581	157	148			24,844
Printing & Repro				0		42	2,712	458	238				3,450
Transportation				1,043	935		0	12,596	2,172	304			17,050
Install Common	0	0	0	0	16	4,776	13	37,978	5,891	1,856	0	234	50,764
Ctr Mgmt & Staff					16	98	13	7,100	557	129		71	7,984
Medical Services								10,971	167	182			11,320
Install Supt Svcs					0	4,678		19,907	5,167	1,545		163	31,460
TOTAL OPER OF INSTAL	0	0	0	1,043	1,003	123,187	3,048	210,131	14,674	7,579	75	356	361,096
(Interagcy Motor Pool)				155	0								155
TOTAL DEPN	855,219	100,872	290	32,043	2,478	123,187	3,048	221,379	14,674	7,579	75	356	1,361,200

11-Feb-86

FILE NAME: T87MARK
FY 1987 SUMMARY

RESEARCH & PROGRAM MANAGEMENT
FY 1987 CONGRESSIONAL BUDGET SUBMISSION
ANALYSIS OF OBJECT CLASS BY SUBFUNCTION
($K)

Function	OC 11 Comp	OC 12 Bene	OC 13 Form Per	OC 21 Tvl	OC 22 Trans	OC 23 R/C/U	OC 24 Prt&Rep	OC 25 Oth Svc	OC 26 Sup&Mat	OC 31 Equip	OC 32 Lds&ST	OC 41-2 G,Con,In	Total
Pers. Compensation	861,937	0	0	0	0	0	0	0	0	0	0	0	861,937
Full-Time Perm Pos.	821,054												821,054
Pos. Other than Perm	15,297												15,297
Reimb. Detailees	7,665												7,665
Ot & Other Comp.	17,921												17,921
Benefits	0	99,923	300	0	0	0	0	0	0	0	0	0	100,223
CS Retirement		56,083											56,083
Fed Grp Life Ins		2,114											2,114
Fed Empl Health Ben		23,144											23,144
Workmen's Comp		5,374											5,374
FICA		3,548											3,548
Medicare		9,660											9,660
Other	0	0	0										0
Former Personnel	0	0	300										300
Supporting Cost	0	3,239	0	0	1,981	0	0	13,485	0	0	0	0	18,705
Transfer of Pers.	0	3,239	0	0	1,981	0	0	0	0	0	0	0	5,220
(PCS Benefits)		3,239											3,239
(Household Goods)					1,981								1,981
OPM Svcs (HQs only)								881					881
Training								12,604					12,604
PERS & RELATED COSTS	861,937	103,162	300	0	1,981	0	0	13,485	0	0	0	0	980,865
Prog. Travel				26,180									26,180
Scient & Tech				3,125									3,125
Mgmt & Operations	0	0	0	4,395	0	0	0	0	0	0	0	0	4,395
NASA non-local				3,817									3,817
Legal & Invitat.				578									578
TRAVEL	0	0	0	33,700	0	0	0	0	0	0	0	0	33,700
Facilities Services	0	0	0	0	0	111,482	0	112,974	4,776	2,382	88	0	231,894
Rent of Real Prop						11,616							11,616
Maint & Related	0	0	0	0	0	0	0	43,230	2,127	2,101	88	0	47,546
Facilities								42,443	2,127	2,024	88		46,682
Equipment								787		77			864
Custodial						7		54,841	454	200			55,502
Utilities						100,059		14,895	2,195	81			117,230
Technical Services	0	0	0	0	43	1,726	335	68,324	2,208	13,616	0	128	86,380
ADP	0	0	0	0	8	1,540	19	52,230	1,069	12,820	0	0	67,686
Equipment					3	1,032		3,926	100	11,861			16,922
Operations					5	508	19	48,304	969	959			50,764
Scient & Tech Info	0	0	0	0	35	186	316	9,841	833	375	0	128	11,714
Library							0	2,480	672				3,152
Educ & Info					35	186	316	7,361	161	375		128	8,562
Shop Support Svcs								6,253	306	421			6,980
Mgmt & Operations	0	0	0	1,973	1,032	26,767	2,853	62,283	10,039	3,130	0	244	108,361
Admin Communicat.					11	21,045		3,542	280	50			24,928
Printing & Reprod				0		45	2,814	503	233	0			3,595
Transportation				1,973	997	2	0	13,885	2,446	435			19,738
Install Common	0	0	0	0	24	5,675	39	44,353	7,080	2,645	0	244	60,060
Ctr Mgmt & Staff					11	216	14	8,620	641	246		76	9,824
Medical Services						422	25	11,630	164	242			12,503
Install Supt Svcs					13	5,037		24,103	6,275	2,157		168	37,753
TOTAL OPER OF INSTAL	0	0	0	1,973	1,075	139,975	3,188	243,581	17,043	19,140	88	372	426,435
				162	0								162
TOTAL DPM	861,937	103,162	300	35,673	3,056	139,975	3,188	257,066	17,043	19,140	88	372	1,441,000

UTILITY SERVICES

Mr. **Green**. Last year, NASA estimated $96,217,000 for utility services in 1985. The actual amount obligated for utilities in 1985 was $85,735,000. What caused NASA's 1985 utility cost to be off by $10,482,000? The current 1986 estimate for utilities is $6,422,000 below last year's estimate of $108,812,000 for 1986.

Mr. **Newman**. There has been less growth in utility rates than we projected and there was a consumption decrease in 1985.

Mr. **Green**. I guess that was the——

Mr. **Newman**. Because of the 40×80-foot wind tunnel being delayed.

Mr. **Newman**. Because of the 40 x 80-foot wind tunnel being delayed.

Dr. **Fletcher**. That can be related to the 40 x 80 also.

Mr. **Newman**. The 40 x 80 wind tunnel is a factor. About $5 million of the $16 million cut, because of the Challenger accident, would be in the utilities area. So instead of $117 million we would be at about $112 million for utilities in 1987. Before that we were projecting an increase in the consumption of about 10 percent related to the 40 x 80 coming on line fully and to the increase in launch rate. We have taken the utility consumption increase due to launch rate out of that. Overall the projection is about 7 percent inflation in utilities. We don't think that is excessive.

Mr. **Green**. Last year NASA estimated $39,728,000 for ADP in 1985. The actual amount turned out to be $42,583,000. What explains the discrepancy? Apparently there was a similar increase in 1984.

Mr. **Newman**. We have been making a deliberate effort to upgrade the automation in the Agency. That is a $2 million increase in 1985 which would be explained by that.

Mr. **Green**. Last year you estimated $55,938,000 for installation common services in 1985. The actual amount was $59,949,000. What explains the $4,011,000 difference?

Mr. **Tulip**. That is related to the $10 million administrative cut in 1986. In 1985 we thought we would reduce some of the services to get ready for the reduction we are taking this year.

As we looked at the way we could achieve the cut amongst the parts of the Management Operations sub-function, we took more cuts in some areas and less cuts in the installation common service area.

If you look at the whole function, it is only off by $2 or 3 hundred thousand from what was estimated last year.

INSTALLATION COMMON SERVICE CONTRACTS

Mr. **Green**. Did the installation common service contracts cost more than anticipated or were the contracts extended into 1986?

Mr. **Tulip**. We were going to make reductions in those services that we decided to reduce but in other areas of the Management Operations sub-function.

Mr. **Green**. Why has the 1986 current estimate for installation common services been reduced from last year's estimate by $1,849,000? It was a $52,613,000 last year and now you estimate this year $50,764,000.

Mr. **Tulip**. It is part of the $25 million Congressional reduction in the 1986 appropriation. We are able to make more economies in those areas than anticipated.

Mr. **Green**. Your 1987 request is $60,080,000 for installation common services. That is an increase of $9,316,000 above the 1986 level. What causes this 18 percent increase and how much of it is the result of higher price levels?

Mr. **Tulip**. About $3 million of it is due to higher price levels and the balance is where we found that we needed to beef up to provide adequate services in support of the research and development program.

MAINTENANCE AND RELATED SERVICES

Mr. **Green**. Last year NASA requested $42,499,000 for maintenance and related services in 1986. This year the 1986 estimate is down to $36,529,000. Again, what causes the variance of $5,970,000?

Mr. **Tulip**. Which year is that?

Mr. **Green**. 1986.

Mr. **Newman**. We are reducing the funding on support contractors that carry forward during fiscal year 1986 as part of our means of complying with those reductions we talked about earlier. And some significant portion is in that area.

Mr. **Green**. Now in 1987 the request is $47,546,000 for maintenance and related services, an increase of $11,017,000 or about 30 percent. What causes that and how much of the increase is estimated to result from contractor price increases?

Mr. **Newman**. Part of it is the full year funding. For that one individual item I cannot answer that.

Mr. **Green**. Could you supply it for the record?

[The information follows:]

The increase from 1986 to 1987 of $11,017,000 in the Facilities Services subfunction is required to provide for the following:

$5,000,000 for Environmental Assessment Studies;
$1,903,000 to provide a full years obligation in FY 1987;
$1,870,000 for minor adjustments in the level of maintenance provided;
$2,244,000 for estimated price increases.

Mr. **Tulip**. The $5 million environmental assessment study is in there.

Mr. **Newman**. Thank you. One of the new items we are proposing in the fiscal year 1987 budget is $5 million to assess environmental hazards such as asbestos in ceilings and so forth.

TRAVEL REQUEST

Mr. **Green**. Turning to travel, you request $33,700,000 in 1987, an increase of $2,700,000 above 1986. How much of that is due to increased cost of travel and how much is additional travel?

Mr. **Newman**. Most of it is attributable to increased costs. Do we have a breakdown?

Mr. **Tulip**. It is about 50-50. It is about 6 percent increase in estimated travel costs, and per diem, and the balance of it is to provide an adequate amount of travel as expressed by the centers to support the contract program.

HAZARDOUS SUBSTANCES

Mr. **Green**. Returning to the $5 million study for hazardous substances, how did you make that estimate?

Mr. **Newman**. The estimate is really an amount arrived at more or less arbitrarily to get started. The actual amount will be more than that.

Mr. **Green**. That is the next question, what do you expect to be the outyear costs resulting from that?

Mr. **Newman**. We really don't know that.

Mr. **Nysmith**. We ran a pilot study in Kennedy on that. And that kind of scoped the level of the study and we expanded it to the other centers. That is how you get to $5 million. Takes about that money to do that job adequately.

ADP

Mr. **Green**. The 1987 request includes an increase of $20,324,000 for ADP, of which $7.4 million is for replacement or upgrading administrative computing facilities at Langley, Lewis, Goddard and Headquarters, and $7.5 million is to begin an Automated systems Development program.

What do you estimate will be the outyear cost of the Automated Systems Development Program?

Mr. **Nysmith**. We anticipate that program will be about that ongoing level. Today we are spending about a million dollars agencywide and that is just not getting the job done.

Mr. **Green**. Do you anticipate that ultimately you would be saving any money by developing this system, and if so, how much and over what period of time?

Mr. **Nysmith**. We anticipate to save certainly the investment in the outyears because that is the whole purpose of the automation process. To start getting payback. You may see people able to move the resources onto the more R&D things out of the administrative functions which takes less people to support.

Mr. **Green**. For what is the balance of the 1987 ADP increase, which amounts to approximately $5 million?

Mr. **Tulip**. The anticipated increase in price levels, and the full year funding of contracts we did not obligate fully this year because of the reductions in our FY 1986 request.

STANDARD LEVEL USER CHARGE REQUEST

Mr. **Green**. The standard level user charge request for fiscal year 1987 is $11,215,000, an increase of $2,596,000 above 1986. Is that 30 percent increase in rental cost due solely to the rate increase or are you proposing to rent additional space in 1987?

Mr. **Newman**. I believe there is no additional space. In fact there is a slight reduction in space and it is due to the increases which occur on the three-year cycle.

Mr. **Tulip**. The value is given to us by GSA and OMB and we will actually rent about 2000 less square feet.

Mr. **Green**. For the record, could you supply information on what the changes are.

[The information follows:]

Standard level user charges are given to NASA by GSA and OMB. The 30 percent increase in rental cost between FY 1986 and FY 1987 is due to the increase in rates charged by GSA. The attached table shows a reduction in rental space of 2,188 square feet but an increase in rental costs of $2,593,000 from FY 1986 to FY 1987.

STANDARD LEVEL USER CHARGES

	Rental area (sq. feet)			Cost		
	FY 1986	Change	FY 1987	FY 1986	Change	FY 1987
Headquarters	532,637	−2,188	530,449	8,093,300	2,496,800	10,590,100
Goddard Space Flight Center	33,213	0	33,213	470,700	96,200	566,900
Total	565,850	−2,188	563,662	8,564,000	2,593,000	11,157,000

FULL TIME PERMANENT WORK YEARS

Mr. **Green**. The table on SUM-12 shows the number of permanent workyears in 1986 to be 21,800, the same number that you estimated last year for 1986. But the number of full-time permanent workyears increases by 107, and that is offset by a similar decrease in other than full-time permanent workyears.

Why is the number of full-time permanent workyears going up and the number of other than full-time permanent workyears going down?

Mr. **Newman**. We placed an emphasis in the past few years on trying to do something about the aging work force by hiring recent college graduates. To do that you need to offset in the temporary program. As I mentioned before, of the 21,800 FTE plan we will underrun somewhat in 1986 because of the freeze actions we have had on.

Mr. **Green**. On page SUM-13 there is a table showing the distribution of permanent civil service work force by program. The 1985 actual workyears for the Aeronautics and Space Technology program is 4,661 versus an estimate last year of 4,982 for that program. Why the shortfall of 321? That is an actual in 1985 of 4,661, when last year you estimated 4,982.

Mr. **Newman**. We will have to supply it for the record.

[The information follows:]

The manpower supporting the Aeronautics and Space Technology Programs is involved in disciplinary activities of a fundamental nature that have synergistic applicability to many other programs being conducted by the Agency. Upon occasion, as required, the manpower within a Center is realigned to meet short term programmatic needs. The 321 workyear adjustment took place primarily at Langley and Lewis Research Centers. These workyears were deployed to meet space station, launch vehicle technology, and space science and application payload program requirements.

Mr. **Green**. Do you still anticipate 4,889 workyears in this program in 1986?

Mr. **Newman**. With the exception that the total would be down about 120 to 150 FTE that I mentioned. Some portion of that will no doubt occur at the aeronautical centers, and therefore that figure will be lower, but probably at the same ratio.

FACILITY SERVICES AT JSC

Mr. **Green**. Turn to the Johnson Space Center. The table on page RPM1-4 indicates facilities services in 1986 decreasing from $33,911,000 estimated last year to the current estimate of $28,990,000. Management and operations in 1986 decreases from $16,625,000 estimated last year to the current estimate of $11,700,000. Part of the reason for the decreases from the 1986 estimates to the current estimate is the result of less than full year obligations in support service contracts. How far into the next fiscal year does NASA normally fund support contracts—three months, six months?

Mr. **Newman**. It varies considerably by the situation in each individual center. We did not run all the contracts coming due on the same day and that is why I think the Committee has wisely put into the language that 12-month provision. We have forward funding of about $12 million.

Mr. **Tulip**. Which is less than a month's funding.

Mr. **Newman**. On the basis of about $174 million in costs annually it is less than a month's average.

Mr. **Green**. How much less than a full year will be funded in 1986 due to budget reductions and sequestration?

Mr. **Newman**. The total now is about $6 million; the $12 million at the end of 1985 goes to about 6 million in this budget for the end of 1986.

UTILITY SERVICES COST AT LRC

Mr. **Green**. Turning to the Lewis Research Center, the utility services cost in 1985 was $10,587,000. Last year you estimated $13,029,000 for utility services in 1985. What caused the utility services at Lewis to be $2,422,000 less than estimated last year?

Apparently there was a similar change in 1984.

Mr. **Newman**. You are comparing the 1985 estimate a year ago with the 1985 actual.

Mr. **Green**. Yes.

Mr. **Tulip**. That is partly due to consumption reduction and partly due to rate increases that had been requested of the Ohio Public Utilities Commission that were not approved.

CIVIL SERVICE RETIREMENT PROGRAM

Mr. **Green**. Congress is currently considering legislation that would, first, revise the civil service retirement program and, second, provide an early out.

How many NASA employees do you believe would be affected by these two legislative proposals?

Dr. **Fletcher**. Mr. Green, are you referring to the Roth bill?

Mr. **Green**. The so-called Roth bill, yes.

Mr. **Nysmith**. We have 9,000 employees agency-wide who would be eligible to take advantage of the Roth legislation. About half of our work force is scientists and engineers, and about 42 percent of our scientists and engineers are eligible for early out. Almost 70 percent of our senior executives. So the Roth legislation would have a very significant impact on NASA.

Dr. **Fletcher**. I would use the word "disastrous."

Mr. **Nysmith**. Yes. We wouldn't anticipate they would all leave, but we would anticipate that probably 20 percent of those eligible—that has historically been the number that have left. So we would expect around 2,000 to leave. Those would be mostly at the higher levels.

REDUCTION OF GS AND GM WORKFORCE

Mr. **Green**. This Administration has been working to reduce the size and cost of the GS/GM 11-15 work force. Last year you indicated NASA was no longer being required to reduce its proportion of the GS/GM 11-15 work force. This is reflected on page 197 of last year's hearings.

How did you convince the Administration that you should be exempt from this overall policy?

Mr. **Nysmith**. Well, in our argument, and it was to take a look at our work force and just the statistics I quoted, that over half our work force are S&Es. One is not a journeyman S&E until you are at that bulge area that I talked about, and they agreed we are an exception, that in fact we should have a bulge in that range or it would not be representative of the kind of agency we are.

So they did agree to that.

Mr. **Newman**. I would like to add that our average grade has been stead at about 11.3 for a number of years, certainly the last three or four years.

Mr. **Green**. The detail of permanent positions table on page SA-36 indicates 14,318 positions in the GS/GM 11-15 category in 1985. The 1986 estimate is for 14,203 positions in that grade range. Last year you estimated 14,174 positions in 1985 in that category and 14,041 in 1986.

Why has the number of positions in the 1985 GS/GM 11-15 bracket increased by 144 above the last year's estimate? The 1986 increase above last year's estimate is 162.

Did that occur in one or two centers, or is it pretty much across the board?

Mr. **Newman**. It is pretty much spread across the board.

We would have to provide more details for the record on that.

[The information follows:]

The increase of 144 positions in grade levels GS/GM 11-15 in fiscal year 1985 from the fiscal year 1986 budget to the actuals reported in the fiscal year 1987 budget was due primarily to actions taken at three NASA Centers.

(1) Goddard Space Flight Center had a net increase of 50 positions at the GS/GM 11-15 grade levels due mainly to the success of the "fresh-out" hiring program (at the GS 11 level) for science, engineering, and related professionals. This hiring initiative is essential for maintaining a balanced workforce and preparing individuals for anticipated vacancies in journeyman positions in the technical professions.

(2) Lewis Research Center had an increase of 57 positions across the GS/GM 11-15 grade levels. This increase was due to (a) their success in the "fresh-out" hiring program which recruited more graduates of science, engineering and related fields than had been planned, and (b) more promotions at the GS/GM 12-15 grades than had been projected in the fiscal year 1986 budget estimate. The promotions are related to the efforts to retain a highly qualified and motivated workforce.

(3) Marshall Space Flight center had a net increase of 103 positions in the GS/GM 11-15 range. This increase was due to an under estimation of the expected on-board at these levels and an increase in hiring and promotions of highly qualified professionals at grades GS/GM 12-14 recruit and train engineers, procurement and financial management personnel.

Actions taken at all other NASA installations resulted in a net decrease of 66 positions at the GS/GM 11-15 grade levels.

Mr. TULIP. We don't control the number by grade at each Center from Headquarters. The number of positions by grade as shown represents estimates by the Centers each December of where they are likely to be nine months later.

They are based upon estimates of losses and hires. Therefore, they will vary by 1 or 2 percent.

The 1985 change is only a 1-percent variance.

Mr. GREEN. Does NASA Headquarters maintain control over the Centers as to the Centers' grade structure, or is that in the hands of the Center director?

Mr. TULIP. We monitor the overall average grade, and watch how it changes by major occupational group. A rise in the number of people at any one grade level is of less concern because it usually means only a change in the mix. We feel overall average grade is a better measure.

We do not monitor by grade other than when we perform periodic personnel management evaluations, about every two years at the Centers, and the appropriateness of classification is reviewed.

Mr. GREEN. How do you determine how much to request for salaries if you are not sure what your grade structures will be?

Mr. NEWMAN. We do get a list from the Center, and we review that. They do price personnel for each individual Center, and we work from that.

Mr. GREEN. Thank you.

Mr. NYSMITH. We don't control it from Headquarters.

The Centers certainly are able to project quite accurately what grade structure they will have.

Mr. GREEN. Mr. Chairman, I have a couple general questions.

Mr. BOLAND. Sure.

Mr. GREEN. I wonder if Mrs. Boggs has questions, though.

SEARCH AND RESCUE PROGRAM

Mr. BOLAND. Mrs. Boggs?

Mrs. BOGGS. Thank you.

I have several general questions, too, but I would like to ask a specific question about the search and rescue program, if I may.

I am very grateful that you were kind enough to keep me advised of the great work of the search and rescue program.

Could you tell me what impact the loss of the GOES, the Geostationary Satellite, and failure of the Delta launch on May 3 will have on the program?

Dr. FLETCHER. Burt has that.

Dr. EDELSON. The loss of the GOES satellite, in general, on stationary orbit will not affect the operating search and rescue program. The situation with that at the present time is that there are four operating search and rescue devices in low earth polar orbits. One is on a NOAA spacecraft. The other three are on Russian satellites.

Mrs. BOGGS. So the loss will not have any effect at all on the program?

Dr. EDELSON. That is correct.

Mrs. **Boggs**. It won't have an effect on not bringing the program even into greater capability?

Dr. **Fletcher**. Mrs. Boggs, I think that is one program that started when I was here and——

Mrs. **Boggs**. I remember.

Dr. **Fletcher**. And I thought it was just a great idea to implement. We do depend on the Russians. That is one program that carried on despite all this noise that is happening. As long as they keep their end of the bargain, there is not indication that they won't, we pretty well are able to cover the Earth with those satellites.

Mrs. **Boggs**. Right.

Dr. **Edelson**. In fact, I have recent figures that were just given to me that to date. There have been 568 lives saved, 50 percent American.

Mrs. **Boggs**. That is a wonderful report.

On Monday, Senator Stevens and I will be dedicating the Boggs-Baggich visitors center in a national park in Alaska. As you know, I became especially interested in the search and rescue program because I felt that we had the capabilities and the Russians had the capabilities and we should merge areas of expert knowledge and work together in a program. I am delighted that so many lives have been saved in such an exemplary cooperative program.

So, I am extraordinarily proud of what you have done in a short period of time, and I was just apprehensive that since there seemed to be a search and rescue component of the satellite that was on the mission that perhaps it had hurt the program in some way, and I am relieved to hear it has not.

Dr. **Edelson**. No, that will not affect the program. We do have a search and rescue package on the next NOAA satellite to be launched which is currently scheduled for launch from Vandenberg Air Force Base on or about the 16th of June.

Mrs. **Boggs**. Thank you.

Dr. **Edelson**. I will agree that it has been an exemplary program from every point of view. It has worked well technically. It is a triumph of international cooperation involving not only the Russians and our country, but also the Canadians and the French, and we are now offering the opportunity to join for other countries, including Brazil and several others. In the most measurable and meaningful terms, it has actually saved 568 human lives.

Mrs. **Boggs**. And countless dollars for the countries in which the rescues were made, because it has minimized the amount of time and manpower and equipment needed for search and rescue operations, particularly for long searches.

Dr. **Edelson**. It has done that, yes, ma'am.

NATIONAL COMMISSION ON SPACE REPORT

Mrs. **Boggs**. When we have had great thrusts of movement and excitement in the space program, it has usually been a Presidential initiative. I am simply wondering what you think is going to happen when the National Commission on Space report finally surfaces on the President's desk. Do you think we are going to have a bold new commitment to the space program from that Presidential perspective?

Dr. **Fletcher**. Mrs. Boggs, I think, by the way, that is going to happen this week, to my understanding. I think in the long run, it will have.

Unfortunately, with all of the difficulties that NASA is having right now, real and imagined, it is going to be hard to get that upbeat notion that comes out of the Paine Commission. On the other hand, over the next year, I think we can regain that momentum and we can begin to address some of the program, at least in the study form that they are about to suggest. I think it is on the right track and we ought to respond enthusiastically.

INTERNATIONAL SPACE YEAR 1992

Mrs. **Boggs**. The International Space Year 1992, of course, coincides with various other anniversaries, including the 500th anniversary of Columbus' discovery of America, and I think it is the 75th anniversary of the founding of the USSR.

I would assume that the Russians, in order to celebrate their 75th anniversary, will also do some remarkable experiments and have some great achievements for the International Year of Space in 1992.

Wouldn't it be a great opportunity for us in preparation for that year to make a great new commitment to the Space Station, the humanistic elements that will be up in space for a long time to come, and to encourage the President to make such a commitment so that we can go forward?

Dr. **Fletcher**. Mrs. Boggs, we are looking at that.

I am not sure. Maybe somebody else can answer whether we have come to any definite conclusions, but I think your statement is right on the mark. We should do something meaningful and visible at NASA in 1992.

Now, having said that, I don't know where that study stands.

Mr. **Morrison**. Dr. Fletcher, the Administration has taken action to respond to the Congress.

NASA was asked to chair an interagency study. That study had been submitted to the White House, and just as with the Paine Commission report, we are expecting it to be forthcoming shortly. It should be in Congress, I would guess, within the next week or two.

Mrs. **Boggs**. Thank you so much.

Mr. Green.

COST OF SHUTTLE FLIGHTS VS. ELV'S

Mr. **Green**. We had a discussion of the costs, and your feeling was that it has been a long time since there really has been a careful analysis of marginal costs of shuttle flights versus ELVs.

For the record, could you give us such a calculation, breaking down what you see as the marginal cost of the shuttle versus the ELV flight, and in a separate calculation, how that is affected by the requirement that the incremental shuttle flights have to be on the replacement orbiter?

Dr. **Fletcher**. Mr. Green, we are in the process of making that study.

Mr. Moser and Admiral Truly are trying to do that, at the same time he is trying to do all these other things on a timely basis.

We will furnish that to this Committee, of course.

[The information follows:]

We have recently prepared a comparison of the costs of performing missions on the Shuttle vs a mixed family of competitive ELV's including the complementary expendable launch vehicle and the proposed new medium expendable launch vehicle system to perform the equivalent launch capability of an STS orbiter i.e., five launches per year. The analysis shows the Shuttle has a dominant economic advantage of about $500M per year in FY 1986 dollars. This analysis was prepared with a Centaur Upper Stage but the substitution of an Inertial Upper Stage would not affect the results since the costs are the same for each alternative.

SUMMARY ECONOMIC ANALYSIS REPLACEMENT ORBITER VERSUS COMPETITIVE DoD EXPENDABLE

ASSUMPTION

Replacement Orbiter is required to provide satisfactory operational fleet and would be available for 5 additional flights per year.

Expendable flights for five Shuttle Equivalent consistent with DoD Supplemental are assumed to be flown with a mix of 3 Titan 34D Segment vehicles, 74% of which use Centaur Upper Stage; and 6 Medium Capability ELV.

ELV costing is consistent with values in DoD Supplemental Request.

[In millions of 1986 dollars]

Recurring STS:	
STS marginal cost per flight	35
Centaur stage	42
PAM DII stage	10
Recurring new expendable:	
Titan III 34D 7 segment	95
Centaur stage	42
Titan launch support	25
Medium ELV vehicle and launch support	63
Annual operations cost 5 STS equivalent launch per/year:	
3 STS, 74 percent use Centaur	198
2 STS with 6 PAM DII stages	198
	327
3 Titans, 74 percent use Centaur	453
6 Med new ELV	378
	830

Recurring Economic Advantage of STS Launches $503 million per year in 86$.

OPERATIONS COST FOR PERMANENTLY MANNED AND MAN-TENDED STATION

Mr. **Green**. Similarly, while in your definition studies you have had calculations of the cost of creating both the permanently manned and man-tended station, I am really coming away from you with a rather fuzzy feeling as to what operations costs look like in each of the modes—if you could, in terms of regular re-supply problems, ground-based monitoring during operations, that kind of operating costs.

Dr. **Fletcher**. That is an awfully good, but also penetrating, question. That is really what we are trying to do with DOT and DoD—to come up with a rational basis for doing whatever is needed to be done. We are going to try to do it in two months, but at the start of the space shuttle program that same exercise took almost two years. But we have to make a first cut at it in that time, and we will supply it to you.

AEROSPACE SAFETY ADVISORY PANEL

Mr. **Green**. Thank you.

One final area, and that is getting back to the Aerospace Safety Advisory Panel.

On the one hand, I have a feeling they did excellent work. Perhaps all of us should have read the calendar year 1984 report more carefully. And so, I certainly don't want to fault the present panel for the very useful work they have done.

On the other hand, that was the obvious breakdown in communications, that they apparently never heard of the O-ring problem.

I am also concerned in looking at the panel that it seems to be primarily retired NASA employees plus people who have been doing business with NASA, and I do understand that they are the ones who know the business best.

On the other hand, it did seem to me that perhaps the panel could benefit from having more outside persons.

Are you looking at what might be done with the panel?

Dr. **Fletcher**. Mr. Green, you are right on the mark, because I happen to be doing just that, starting yesterday. It is a statutory commission, so we have to be careful how we ease people in. There is an opening right now, and I am trying to see if I can't do just what you have suggested by bringing in somebody that has had experience in safety but not in the space arena. Whether that takes place or not, we are still debating that. We are on a short fuse. But on the other hand, the next time a replacement comes up for consideration, we are going to do that.

I am not familiar with the ground rules on whether we can enlarge that commission size, but nevertheless, we will address your point.

Mr. **Green**. Maybe you need legislation, and if you want it we will be glad to consider that.

Dr. **Fletcher**. At this point I am not familiar with the restrictions.

Mr. **Green**. Along with the Science and Technology Committee.

Dr. **Fletcher**. Whatever the case, I am personally planning to do just what you have suggested.

Mr. **Green**. Thank you, Mr. Chairman.

ORBITER PROCESSING FACILITY AT KSC

Mr. **Boland**. I am confused about the Orbiter Processing Facility at JFK. That is a $3.4 million request to get rid of the trailers north and west of the facility, is that correct?

I think you indicated that this was going to house one of the orbiters.

Last year we provided $14 million in order to provide for modification of the Orbiter Processing Facility. As I remember, the hearings reflect that one of the orbiters was being stored in the vehicle assembly buildings; apparently, you wanted to get out of there.

For what did you use the $14 million that was provided last year, General McGarvey?

General **McGarvey**. There is an orbiter refurbishment-facility——

Mr. **Boland**. To house it.

General **McGarvey** [continuing]. And repair facility now under construction.

Mr. **Boland**. So you have three orbiters in that processing facility now, is that correct?

General **McGarvey**. The third facility for housing the orbiter for off-line repair and refurbishment was just awarded in February this year, with money which was appropriated last year, $14 million.

Mr. **Boland**. The $3.4 million is only for the purpose of providing office space and, apparently, living space for—it is really office space, isn't it?

General **McGarvey**. No, sir. It is space for marshalling the crews——

Mr. **Boland**. But this $3.4 million is not used to store an orbiter, is that correct?

General **McGarvey**. That is correct.

Mr. **Boland**. Okay.

General **McGarvey**. Strictly support space.

AIR FORCE ON DELAYING THE SHUTTLE

Mr. **Boland**. Let me ask you, you indicated the Air Force was studying delaying the shuttle, and one of the paragraphs of this *New York Times* article indicates that, " 'The real advantage of putting Vandenberg into mothballs,' the Air Force said, 'is that it allows NASA and the Department of Defense to increase the number of launchings each year while a fourth orbiter is built.' "

I guess that would be so, too, wouldn't it?

Would anybody disagree with that?

Dr. **Fletcher**. One of the problems with that article which I read, Mr. Chairman, is that they assume things that have not yet happened, namely that the fourth orbiter will not be available until 1991, and that would be true if we don't get cracking pretty soon.

And as you have pointed out in your earlier hearings, if we don't get cracking pretty soon, not only the fourth orbiter will be in jeopardy, but possibly the Western Test Range which we desperately need for our own purposes but which the Air Force also needs for its purposes. So, we are working the problem.

That article does reflect a strengthening of the rumor that we discussed last time. It is not a decision, but it is becoming higher on the agenda of the Secretary of Defense. We are working the problem with the Defense Department.

CLOSING REMARKS

Mr. **Boland**. Okay.

Well, we have come to the end after two and a half days of rather extensive hearings. We want you to understand that we would be willing to help the Administration in whatever way it believes it should be helped, at the same time keeping in mind that we have the responsibility of staying within whatever allocation is handed to us under this Committee's 302(b) allocation.

And we have no room at the present time in that allocation to provide for the fourth orbiter. So, that is a problem that we will have.

In any event, you can be very sure that any assistance this Committee can give, we will.

So, Dr. Fletcher, Dr. Graham, Mr. Nysmith, Phil, Mr. Aller, General McGarvey, and Tom, thank you all very much—everybody in the room.

John Murphy, thank you for your testimony. I have enjoyed it for the past two and a half days.

Mr. **Murphy**. It has been a very great pleasure to be with you, sir, as usual.

Mr. **Boland**. Anyway, have a good weekend.

Thank you very much.

[Questions for the record and the answers thereto follow:]

Questions Submitted by Congressman Traxler

Question. What is NASA planning during this hiatus in flights to maintain a vigorous space science activity? What is NASA planning to most effectively utilize its OSSA resources to prepare for the resumption of shuttle flights?

Answer. As the impact of the Challenger accident is being assessed, we will strive to maintain a vigorous level of ground-based activities during the launch hiatus. Our Space Science and Applications program has sufficient breadth and momentum to moderate some of the impact on space research opportunities by using to the fullest extent our operating spacecraft and the various other elements of our ground research programs.

About twenty earth-orbiting and solar system exploration spacecraft continue to provide high quality data that can support important research in many disciplines; astronomy, solar and space physics, planetary science and earth science. We will continue to ensure the broadest use of these ongoing missions.

We will also work to maximize the use of Research and Analysis—laboratory and ground-based experimentation, sub-orbital flights, theory and modeling, and advanced instrument development—to keep the space and earth sciences as vigorous as possible pending the restoration of shuttle flights. The momentum and balance between research and flight projects so carefully cultivated in the past will help carry the program over the difficult post-accident period.

In our current round of budget deliberations, we will address the problems of maintaining science program momentum as part of our overall recovery strategy for the science and applications program.

Question. In testimony before this subcommittee, the Space Science Working Group suggested that enhancement of budget for the Suborbital programs would go a long way to keep the NASA-supported space science research enterprise active and productive. What is your assessment of this recommendation? In NASA planning to do any of these?

Answer. NASA's space science program provides a unique opportunity to moderate impacts associated with budgetary restraints and the launch hiatus caused by the Challenger accident, and also ease community concerns related to the perception of severe science setbacks. A critical means to accomplish both of these goals will be to focus attention and support upon maximizing the utilization of operational spacecraft and research based programs, including the suborbital program which includes Sounding Rockets, Balloons and aircraft.

NASA's fleet of earth orbiting and solar system exploration spacecraft continue to provide high quality data for support of research in astronomy, solar and space physics, and planetary and earth sciences. The broadest use of these ongoing missions must be ensured by sustaining strong support for productive science and guest investigator programs. It is our intention to focus attention to this important area.

The Stabilizing role of NASA's Supporting Research and Technology (SR&T) programs has been heightened in importance. The space science program has always cultivated synergism between SR&T and flight programs, and, with a concerted effort to focus resources on those areas where they will be most beneficial, this balance can carry the program over the difficult post-accident period. It is our plan to continue this process.

NASA will be looking critically at how to maximize science returns from operational spacecraft, research and analysis, and suborbital programs to keep the space sciences program as vigorous and productive as possible during the hiatus in Shuttle flights.

Question. The revised FY 1986 operating plan reflects current year reductions in Research and Analysis, Data Analysis and Suborbital programs that are greater than the mandated 4.3 percent reduction. In addition, university investigators report that some Data Analysis programs, which are funded at very modest levels, have been reduced sharply in the current year. What is NASA's plan for space science? Why are these programs being reduced.

Answer. In reviewing the total space science budget, special attention is being given to those areas (Mission Operations and Data Analysis, Research and Analysis, and (Suborbital) which will provide the greatest scientific benefits during the Shuttle launch hiatus.

In facing the current budgetary constraints, NASA is conducting critical assessments of all programs, including data analysis, research and analysis, and suborbital, to determine the most effective utilization of available resources. These areas provide unique opportunties for keeping the space science research program vigorous, and NASA has a responsiblity to address issues such as productivity and utility in its research based programs, just as for flight programs.

Because of its heightened importance to the space science community, Research and Analysis funding was reduced by a smaller percentage assessment than other program activities, in the overall OSSA reductions in the FY 1986 budget. (See attached table for breakdown of major program activities.) The Research and Analysis programs were affected by a somewhat larger percentage reduction in the Gramm-Rudman round of budget reductions, because these activities had been "protected" in the first operating plan and the initial Challenger impact adjustments reflected in the second operating plan. If all of the changes in the FY 1986 budget process are taken into account (i.e. compared with the initial President's budget request), Research and Analysis funding has been impacted much less than other OSSA program activities.

[The table referred to above follows:]

OFFICE OF SPACE SCIENCE AND APPLICATIONS, BUDGET BREAKDOWN BY ACTIVITY, FISCAL YEAR 1986

[Dollars in millions]

	Congress request	Ops. plan No. 1	Ops. plan No. 2		Net program	Percent reductions	
			GRH	STS impact		GHR cut	Total cuts in FY 1986
Flight projects	$730.4	−$31.4	−$26.3	+$26.6	$699.3	−$3.6	−$4.3
Shuttle payloads and integration	223.7	−25.6	−17.0	−9.3	171.8	−7.6	−23.2
Mission operations and data analysis	253.1	−14.1	−10.7	−13.7	214.6	−4.2	−15.2
Research and analysis	406.0	+6.4	−21.6		390.8	−5.3	−3.7
Total OSSA	1,613.2	−64.7	−75.6	+3.6	1,476.5	−4.7	−8.5

Redistribution and reduction of Mission Operations and Data Analysis funds were based on a variety of developments; launch delays of two planetary missions (Galileo and Ulysses) reduced funding requirements for mission operations in that area, and reduced data return capability of instrument complements on some older spacecraft has required redistribution of data analysis funds.

In summary, NASA's ability to maintain a strong space science program rests on our responsiveness to the science community's needs in terms of productivity, utility and effectiveness of our research based programs. Attainment of this goal requires constant critical assessment of resource allocations to ensure that scientific benefits are maximized subject to overall budgetary constraints.

We are currently reviewing all of our programs with the intent of utilizing our limited resources to maximize scientific returns in these important activities.

Question. Mr. Chairman, in response to one of your questions on May 20, NASA indicated that the first Orbital Maneuvering Vehicle requirement for a mission would be in 2½ years the launch of Space Telescope. Moreover, NASA indicated that if funding for OMV in Fiscal Year 1987 were to be cut from $70 million to $50 million, the OMV launch date could slip to September of 1991.

My question, for Admiral Truly is: where does Space Telescope fit in with the tentative shuttle manifest? Earlier than the 1989 launch one estimates by backing up from a prospective 1991 OMV mission? If so, would any further slippage in the OMV's first mission—beyond September 1991—be acceptable?

Admiral Truly, would you outline the space transportation advantages of having an OMV on orbit as an adjunct to the orbiter fleet?

Could the OMV, for example, assist in moving structural pieces from Shuttle orbit to Space Station orbit, assisting in the assembly of the Space Station and taking some of the burden off Shuttle requirements?

Answer. Assuming an 18-month stand down, we project that we will be able to launch the Hubble Space Telescope in early 1988.

The initiation of system development for this project is required to maintain program momentum and preclude loss of experienced contractor personnel. Space Telescope can be launched in 1988 or 1989. The servicing requirements by OMV is scheduled nominally for three (3) years after launch. However, depending on solar activity during this time, this could vary by +/−6 months; i.e., 2½ years to 3½ years or some time in 1991. Even if there is a delay in the Space Telescope schedule, the OMV operational date should not be delayed by later than the fourth quarter CY 1991 for first launch of the OMV.

Slippage of the OMV's first mission—beyond September 1991 could compromise the early efforts associated with the initial study, and program definition already conducted on this project. The slippage could also affect OMV support for basic Space Station activities by transferring and maneuvering of models and logistics equipment.

The OMV can reduce Shuttle mission complexity and flight stresses for the low earth orbit payloads delivery and retrieval missions and thereby reduce flight risk.

OMV can deliver payloads to orbits above 150 nautical miles (nmi) more efficiently than the Shuttle. It can reboost and/or retrieve the Space Telescope and other large scientific satellites at desired orbits which the Shuttle cannot reach and thereby extend their operational life and reduce program support cost.

For polar orbit missions, OMV is critical to meeting scientific and DOD spacecraft delivery requirements without major upgrades to the Shuttle.

OMV can retrieve, over extended ranges, spacecraft which have experienced equipment failures or require servicing. This improves Shuttle support and eliminates the need for complex maneuvering of the Shuttle in orbit.

Yes, the OMV will be used to support the basic Space Station activities by transferring and maneuvering of modules and logistic equipment.

Questions Submitted by Congressman Lewis

Question. Mr. Fletcher, several years ago in hearings before this subcommittee, Chairman Boland asked you whether you believed that OMB possessed the engineering and technical expertise to properly distribute budget ceilings among various NASA projects, and, at the program level, overall ceiling caps.

You answered at the time that OMB relied on the White House science office for guidance.

Knowing that you haven't been with us all this time, but as best you and your team have a feeling for historically, has the NASA leadership been satisfied with the level of review given the technical consequences resulting from various budget ceilings placed on NASA programs during the formulation process?

Is there a mechanism in place specifically to review these types of repercussions? Is there written analysis involved in this process?

Answer. In general, NASA has been satisfied with the review given the technical consequence of the budget decisions during the formulation process. During the budget process, the discussions concerning the implications of certain budget decisions usually focus on total funding levels and the programmatic impact of various alternatives. The budget process includes an avenue for appeal at every level, culminating with access to the President by the Administrator when a particular issue cannot be resolved. This process results in the decisions reflected in the budget which is presented to Congress.

Question. I have attached to these questions a table, prepared by the NASA budget office illustrating the differences in overall funding given the Apollo and the shuttle programs, in then year, and in FY 1985 dollars.

We are about to embark on the development phase of the next large space project, the space station, and I for one am committed to avoiding any compromises in the efficiency and performance of the system based on a save now, pay later principle, especially in light of the station's implications as an instrument in international affairs, and the anticipated earth benefits from the potential onboard experiments.

I understand that the original NASA proposal for station was $13 billion in then year dollars. And that through one process or another, final approval was set at $8 billion in 1984 dollars.

Could you provide for the record the total government investment made in station, by fiscal year, translated into 1984 dollars per fiscal year?

Can you outline the total industry and foreign government investments already made, per entity, and in total, and state what the total investment for both is projected to be through IOC, and, as much as possible, through the program's run-out?

I understand that in the change from the $13 billion level to the $8 billion level, in addition to those modules and larger items mentioned before the subcommittee on May 19, 1986, we also lost an OMV with a smart manipulator arm for station's exclusive use; now we must share one between shuttle and station.

We also lost development of an advanced space suit, presumably one that, among other things would enable freer movement in order to facilitate the rigorous manual tasks involved in assembling the station.

In view of the changes in scheduling we've all come to accept as being part of package in creating new technologies, is it realistic to assume we can do with sharing the OMV between station and shuttle?

What else was lost in the process of arriving at the $8 billion figure?

How much in terms of capability, efficiency and redundancies are involved with these items? Can we achieve excellence in the assembly process without them. How much would these items have cost us?

Answer. NASA has invested the following in FY 1984 dollars:

[Dollars in millions]

Fiscal year:	
1983	$4.2
1984	16.4
1985	146.7
1986	169.4
Total	336.7

Estimates of total industry investment to date as provided to NASA by many, but not all, of the contractors and subcontractors, is approximately $500 million in real year dollars. The foreign government investments through Phase B as reported by the foreign governments are approximately: ESA—$80 million; Japan—$25 million and Canada—$10 million with all having been converted to approximate FY 1984 U.S. dollars. The total investment by foreign governments through IOC is estimated at $3 billion U.S. FY 1984 dollars.

The actions that resulted in a reduction in the estimated cost of the Space Station from approximately $12-13 billion dollars to $8 billion dollars fall into several main areas. The first area involves hardware adjustments. By considering the extent of the proposed international participation, increasing the size of the basic common module, and utilizing previously developed hardware, approximately $1.8 billion worth of hardware was not necessary and was removed from the baseline configuration while retaining nearly the same amount of internal volume.

The next area can be characterized as content and/or hardware revisions. All of the major Space Station subsystems were carefully reevaluated to determine the extent to which capabilities satisfied user requirements, and the appropriate adjustments were made. In many cases, the subsystems oversupported the requirements, and considerable savings were realized. In addition, the reduction in the number of modules and changes in the concept of the logistics modules enabled the program to reduce the connecting hardware and outfitting efforts substantially. The uncertainty of some aspects of international participation led to the addition of another U.S. platform. Finally, to retain certain hardware and technology options, the addition of some funds was required. In total, content and/or hardware revisions accounted for a net reduction of approximately $1.2 billion.

The final series of actions can be categorized as program management revisions. The development contractors have indicated that employing new ways of doing business will result in substantial savings to the program. The program also elected to assume additional non-safety-related programmatic risk by reducing the level of reserves to be maintained. These actions resulted in the savings of approximately $800 million.

Question. Your FY 1987 budget proposal to the Administration for station was originally $600 million, and the official request is $410 million. Building on Mr. Green's comments yesterday about the differences in approach and level of detail achievable between the Apollo and shuttle projects, with regard to time spent on design options and out year repercussions from cuts in development funding, including the effect on presumed operations costs, what have we lost with this decrease if we intend to keep the President's schedule for station in the 1990's?

Answer. The funding profile contained in the FY 1987 Congressional request requires the first element launch to be slipped until 1993, but still allows a permanently manned configuration, consistent with the President's mandate, by 1994.

Further assembly of the full baseline configuration Station will continue with the completion in 1996. Previous budget runouts in FY 1985 and FY 1986 contained enough up front funding to allow a rate of hardware buildup that not only met the President's schedule, but also provided a greater schedule margin during the integration, assembly, and check out and systems test operations phases to correct unforeseen anomalies without adversely impacting the launch schedule and subsequent operations.

Question. Has the design option phase leading to a choice of configurations been compromised at all due to the funding level?

Answer. The design option has not been compromised by our $410 million request. The primary impact in the definition line item, as a result in the change from the $600 million budget, to the requested $410 million FY 1987 budget was a reduction in transition funding. We fully expect the Phase B contractors to sustain their teams during the transition period by the use of company resources to augment the funding from the NASA budget. The activity during the definition phase and during the transition period will, therefore, not be impacted.

Question. What would any further decrease below the $410 million do to the schedule or alternatively, to run-out costs, operations costs, and to the thoroughness with which we approach development assuming the schedule will be kept. Please answer in the specific and tailor your response to the possibility of a $50 million or $100 million cut, alternatively.

Answer. If the cuts were to be taken from phase C/D, a $100 million cut would result in the Phase C/D contract starts being postponed until the beginning of FY 1988, with only a small amount of supporting development work occurring in FY 1987. Then, if the funding levels of subsequent years are held at the currently projected levels, the program would experience both a schedule slip and an increase in run-out costs. The $100 million cut, which would result in the loss of a full five months of Phase C/D effort in FY 1987, would make it impossible to achieve the President's mandate of a permanently manned presence in space by 1994. Cuts of less than $100 million could affect some of the contracts planned to be started in FY 1987. A $50 million cut would require a staggered start of the Phase C/D contracts, with only two of the contracts started in FY 1987. If such a cut is made, the only way to hold the schedule and prevent substantial increases in run-out costs would be to add back the money in FY 1988, thus permitting a more rapid rate of development to get back on schedule.

Question. What studies have been done about the compatability and cost of using ELVs with the station, as a back-up to the shuttle. Is this a feasible back-up, either for the United States or our allies?

Answer. NASA is conducting a technical feasibility analysis as to how ELVs could be used to support Space Station needs including assembly and operation. Space Station evolution and scarring could also be affected by the use of ELVs. NASA anticipates having preliminary data as to the technical feasibility, cost, and scheduling of partially sustaining the Space Station by ELVs during early FY 1987.

Question. Regarding the orbiter, at a meeting with Donald Regan, and the SIG-Space group last week, the question of building a replacement orbiter was discussed in context of upgrading or pushing shuttle technology without rendering the vehicle incompatible with existing launch facilities, so as not to significantly increase the overall cost of replacement.

Could you give the subcommittee some means of measuring what a feasible degree of upgrading is, and to what level of technology could that bring the new orbiter?

Answer. The projected replacement Orbiter will include a number of high technology upgrades presently planned for the existing Orbiter fleet. These improvements have been undertaken for several reasons including safety, performance enhancements and long term logistical support.

The most significant of these improvements include the following:

(1) An improved General Purpose Computer to provide double the capacity, triple the speed, and higher reliability electronic parts as compared to the present computer.

(2) An improved Auxiliary Power Unit to achieve a fourfold increase in life and reduce ground turnaround time.

(3) An improved brake system using structural carbon in lieu of beryllium to provide approximately 50 percent increased capacity and high strength retention compared to the baseline brakes.

(4) An upgraded Nose-Wheel Steering System to allow its use as the primary steering system.

(5) An alternate Inertial Measurement Unit that reduces weight, increases launch hold capability and requires fewer on-orbit alignments.

With these upgrades the Orbiter will remain the most advanced space vehicle in the world.

Question. Has the Air Force made an official decision to restart the Atlas and/or Delta lines? I understand they have indicated publicly they plan to re-start the Atlas, which could relieve the civilian sector of start-up costs. They also relieve the civilian sector of start-up costs. They also plan to order 13 more Titan 34-D7s, in addition to the ten presently on order, totaling 23, possibly enough to spare 2 vehicles in the event that NASA would need to use them to launch GALILEO and ULYSSES. What is the status of decision on these options at the Air Force?

Answer. Regarding the Air Force plans, you should request this information from the Air Force. It is our understanding that the Air Force intends to develop a medium range launch vehicle (MLV) and procure 12 vehicles to be launched at a rate of four per year. The new system is to have a payload capability for launching GPS satellites as a supplement to the GPS launches scheduled for the Shuttle. A number of systems are candidate vehicles for this development although the actual selection will be determined by competition.

The Air Force plan to procure 13 additional Titan 34D7 complementary expendable launch vehicles (CELV), is also contingent upon the approval of the FY 1986 supplemental budget request. In their most recent assignment of payloads to the total 23 CELV's there were two potential spare launch vehicles which could be used to launch the GALILEO and ULYSSES planetary spacecraft should safety considerations regarding the RTG/Shuttle or the Centaur/Shuttle combinations lead to a decision to launch these spacecraft on expendable launch vehicles. We have also begun to examine the possibility that the Shuttle and the CELV could exchange payloads in the cases of GALILEO and ULYSSES with the Shuttle launching a dual compatible DOD payload presently scheduled on a CELV to free the CELV to launch the planetary spacecraft. We are also examining the option of using alternative upper stages for the missions.

Question. One very real factor that will play into the viability of a commercial launch industry here is whether or not the parties involved can get insurance for the payloads.

Could you update the subcommittee on the status of this issue, and has that factor seriously entered into the SIG-Space evaluations of viability?

Answer. Clearly, the loss of the Challenger and four ELVs, including the European Ariane, has created insurance circumstances substantially different than those of the preaccident era. Insurance has been obtained since the Challenger for a payload launched in February by the Japanese government. The long term effect of these launch vehicle losses on insurance availability and cost is unclear. We are not aware of any consideration of this factor by SIG-Space, however the Commercialization Space Working Group, in support of the Economic Policy Council is considering these and other issues related to commercial impact of U.S. launch recovery strategies.

Question. Assuming that the first delivery of ELVs appropriate to launch commercial satellites is unlikely to be before 1989, and assuming that in the next generation commercial satellites will be larger, with greater capacity, thus reducing the number of launches necessary to keep up with demand, during what period of years could a private ELV industry hope to make a profit on ELVs, of the Delta and Atlas class?

Answer. First deliveries of ELVs could be achieved in 1988. Consistent deliveries at 4 per year or higher could not be achieved until 1989. It is not clear that all or even most commercial communication satellites will be so large they cannot be accommodated by Delta and/or Atlas class ELVs. Presumably, the builders of satellites will continuously assess the economics of various size satellites including the associated costs and risks of transportation, insurance, success probability, traffic rate, type service required, etc.

The bottom line is that if the overall economics/risk of a ELV is superior to other approaches for satisfying a given payload requirement, then future satellites will be built to the appropriate size to be accommodated by that vehicle.

A private ELV industry can make a profit (a percentage of total business costs) if they are successful in competing to be selected to provide the transportation. How long it would take to make a profit would depend on their changing policy, their launch rate, insurance costs, set-asides for failure investigation, and other expenses. With these variables in such a state of change (witness the last Ariane flight and its impact on insurance rates), it is impossible to assess the time for commercial venture to turn a profit. It is interesting to note that we believe the first real commercial venture in Shuttle upper stages has yet to make any profit after six years and over twenty launches.

Question. I understand there are approximately 30 corporations that are totally dependent for business on the shuttle system. Could you provide a list of these for the record, and indicate their present financial conditions, assuming an 18 month down time.

Answer. The specific number of 30 is not recognized. There are some corporations fully committed to the Shuttle such as Orbital Sciences Corp., Astrotech Space Operations, Inc., and SPACELAB, Inc. Additionally, there are many firms that, while not solely dependent on the Shuttle, have invested considerable funds for developing and manufacturing Shuttle dependent products. Among these are McDonnell Douglas, Boeing, and Grumman Corp. Also, Kodak, IBM, 3M, GM, Deere, Rockwell, MRA, ISC, McDonnell Douglas and many others have made significant investments in Shuttle dependent space experiments with the potential of leading to space commercialization. The number of firms is approximately 43 and their total financial commitments are not known.

Question. I must admit to being concerned last week during our discussion that none of NASA's highest level officials were aware of what had transpired in the preceding several weeks on the international front regarding particularly the Japanese and French responses to our grounding.

It was reported in the trade press last week that the French national center for space studies expressed sentiment in Europe that the U.S. can't build a Space Station adequately on only three or four shuttles.

Defense Daily also reported approximately three weeks ago that the Soviet deputy foreign trade minister made a first time proposal to the Japanese during a three day conference between their business and trade groups—that the Soviets could launch large Japanese satellites on a commercial basis.

Is there a special high level official at NASA who keeps track of international competitiveness and cooperative activities across the broad spectrum, and is responsible for reporting emerging trends and reactions directly to the Administrator?

Answer. The NASA Director of International Affairs is responsible for monitoring foreign programs to determine trends abroad and reactions to NASA programs. The Director of International Affairs works directly with the Administrator and other senior NASA officials and keeps them informed of significant foreign developments. He alerts them to foreign capabilities that represent competition to U.S. programs and those that offer potential for cooperative activities. In addition, the Assistant Administrator for Commercial Programs works closely with the International Affairs Division to keep abreast of foreign competitiveness.

[Surveys and Investigations report and budget justification follow:]

NOT FOR RELEASE UNTIL AUTHORIZED BY THE COMMITTEE

May 30, 1986

MEMORANDUM TO THE CHAIRMAN

RE: The Shuttle-Centaur Program

By directive dated March 19, 1985, the Committee requested an investigation of the Shuttle-Centaur Program.

This investigation has been completed and the results are presented in the attachment to this memorandum.

Respectfully submitted,

R. W. Vandergriff, Jr.
Acting Chief of the Surveys and
Investigations Staff
House Committee on Appropriations

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THE SHUTTLE-CENTAUR PROGRAM

Shuttle-Centaur Program Background Data

In May 1981, the National Aeronautics and Space Administration (NASA) decided to adapt the Centaur vehicle as a Shuttle upper stage to provide the performance required for high energy earth escape missions such as Galileo, Ulysses, and Venus Radar Mapper. In December 1981, program activity was halted because of a debate regarding the most efficient and most effective manner in which the Galileo and Ulysses missions could be performed. In July 1982, the program was restarted with plans to design, develop, test, and build two G-Prime Centaur vehicles and their support systems to launch the NASA Galileo and Ulysses interplanetary spacecraft from two separate Shuttle missions, both during May 1986.

In early 1983, the Shuttle-Centaur program was expanded when the Department of Defense (DOD) added an intitial order for two of the shorter Shuttle-Centaur vehicles, designated Centaur-G, to be delivered in 1986. A proposal was submitted, negotiated, and finalized in April 1984 for the two Centaur G vehicles which were added to the initial developmental contract. Approximately 60 percent commonality exists between the two versions (G and G Prime). Subsequently, a follow-on production contract for three additional Centaur-G vehicles was definitized with General Dynamics Aerospace Division. Thus far, General Dynamics is under contract to deliver seven Centaur vehicles; three for NASA and four for DOD.

The Shuttle-Centaur program marks the first space launch combining a manned vehicle with a payload powered by highly combustible liquid cryogenic fueled engines. Because of the significant risk to the Shuttle and the crew, rigorous safety rules have been implemented that require the Centaur to be dual fault tolerant. That is, if any two components in a system fail, the basic functions of the system will still be maintained. Program officials believe that, although this stringent requirement is very costly, system duplication is necessary to protect human lives and the national assets at stake.

Cost Analysis of Shuttle-Centaur Program Up to the Challenger Accident

At the end of March 1985, both NASA and General Dynamics officials stated that although "the schedule was tight," the program should have no delays or cost increases. However, less than one month later a projected $121.2 million overrun was reflected in the NASA April 1985 highlight--from $755.7 million to $876.9 million. Also, it should be noted that this estimate did not reflect program cost growth associated with Venus Radar Mapper, additional DOD missions, etc. The chart below depicts the projected cost overrun by category.

Shuttle-Centaur
Projected Cost Overrun

	FY 1986 Budget Submittal	Projected Cost Over-runs	April 1985 Submittal
	------------(	$ in millions	)------------
Design, development, test, and evaluation --	$378.9	$ 63.6	$442.5
Galileo/Ulysses operations ------------	194.0	36.8	230.8
DOD 1&2 spacecraft ------------	182.8	20.8	203.6
Total ---------------	$755.7	$121.2	$876.9

The projected cost overrun of $121.2 million included contingency funds of $69.4 million. NASA included these costs as a hedge against further potential problems such as safety issues and engineering changes driven by new or revised requirements. In mid April 1986, NASA headquarters reported that the cost overrun at the time of the Challenger accident had increased by $13 million to $134.2 million. This increased program costs from $876.9 to $889.9 million. Post Challenger accident cost estimates are addressed separately in this attachment.

NASA and General Dynamics officials agree that several serious engineering miscalculations, such as the design of the forward fuel tank bulkhead and the cryogenic fluid valves, significantly contributed to this cost overrun. They also agreed that safety related issues had become much more costly than initially anticipated.

Delays and Safety-Related Improvements Which Will Further Increase Program Cost

On March 25, 1986, the Investigative Staff provided the Committee information addressing NASA's cost estimate of between $160 to $180 million, to cover launch delays and to make necessary safety-related modifications and improvements. This estimate included the $13 million pre Challenger accident cost overrun. These estimates are now projected by NASA to be between $158.1 million to $170.1 million not including the pre 51-L cost overrun of $13 million.

The Associate Administrator for Space Flight stated in a May 7, 1986, memorandum that NASA should be in a position to address all Shuttle-Centaur safety issues and to report this assessment to Congress. He has directed officials from the

Johnson Space Center (JSC), the Lewis Research Center (LeRC), the Kennedy Space Center (KSC), and their contractors to brief him on program safety issues during the week of May 26, 1986. He stated that this briefing should result in the Administrator being able to address questions raised by a Committee letter to NASA dated April 9, 1986. These questions were:

-- Will the total Shuttle-Centaur system, given the successful incorporation/completion of planned enhancements, be safe to fly?

-- What is the estimated cost?

-- When will the Centaur be ready to fly?

NASA officials stated they were uncertain as to when the new Administrator plans to officially respond to these questions.

NASA officials provided the following cost estimates on the latest mission model which has not been formally approved. This mission model indicates that Ulysses will be launched in August 1988 and Galileo in January 1989. NASA officials provided the following cost estimates with a caution that they are "ballpark figures" that are yet to be refined or approved.

Estimated Cost Increases
for Launch Delays and Program
Enhancement/Improvement
-------($ in millions)-------

Launch delays	$ 102.0
Hardware changes to meet original requirements	18.1
Hardware changes to meet post 51-L New requirements	4.3
Technical documentation review and analysis	5.3
Engineering concerns under study	13.9
Implementation of major engineering changes	$ 14.5-26.5
TOTAL	$158.1-170.1

NASA and General Dynamics officials agree that the successful completion of these safety enhancements/improvements should increase Shuttle-Centaur safety. A discussion of these cost estimates follows.

Launch Delays

NASA's initial cost estimate of $76 million to delay the interplanetaries was based on planned launches in July 1987 and August 1988. LeRC has not yet been tasked to determine the cost impact of delaying one launch from July 1987 to January 1989 since this mission model change has not yet been officially approved. A NASA official estimated that the cost of maintaining the marching Army to make enhancements/improvements and to conduct all required testing of Centaur systems from now through January 1989 should require no more than $102 million. He cautioned, however, that this delay time is based solely on the first Shuttle-Centaur being ready for launch by August 1988. He stated that he believes this goal to be achievable, but that it is predicated on the Shuttle being operational by July 1987. He concluded that any slippage in the July 1987 Shuttle operational date may further impact the interplanetary flight schedules.

Hardware Changes to Original Requirements

The following provides a breakout of the estimated cost associated with hardware changes to original requirements.

Estimated Cost Increases
to Meet Original Hardware Requirements
($ in millions)

Redesign/retrofit Fairchild valves	$13.80
Retrofit pins in the Centaur Integrated Support System (CISS) 3-gimbal ducts	.50
Redesign liquid oxygen tank bubble ring	.25
Install deploy adapt engine bell rub rails or bumpers	.08
Redesign Centaur deployable antenna	.33
Replace existing Struthers Dunn relays in control units, and in the dual failure tolerant arm/safe sequencer	3.00
Provide 4 additional control unit networks for dump valve control	.18
TOTAL	$18.14

The largest cost increases are for the redesign of the Fairchild valves and the purchase of control unit relays. Costs to design and to develop these Fairchild valves have grown from the original contract amount of $8 million to the current estimate of approximately $40 million to complete, which include the most recent $13.8 million increase.

Last November, during cold flow tests conducted at KSC the dual actuator cryogenic valves operated erratically during testing when only one actuator was used. This resulted in an abort dump system which did not meet safety requirements for single failure tolerance. The quick fix was to remove an orifice and to operate both actuators simultaneously. This fix eliminated the required redundancy in the abort dump system, but program officials agreed that the valve was flight worthy after successful tanking tests were completed in January 1986.

Since the Challenger accident, program officials and the flight crews have decided that the dump valve should be redesigned to improve actuation margin. As shown above, the redesign cost has been estimated at $13.8 million. Fairchild officials feel comfortable that they can meet an August 1988 launch.

From the program outset, NASA has had problems with the control unit relays. NASA officials stated that the faulty relay switch problem is not unique to NASA, but is an industry-wide problem. These officials stated that in addition to poor quality, NASA has also had a problem in obtaining the quantities of relays needed. To insure there are enough reliable relays available, NASA is purchasing, from two suppliers, twice the number of relays needed to equip the five control units on each CISS.

Hardware Changes to Meet Post 51-L New Requirements

The following provides a breakout of the estimated cost associated with changes required to meet post Challenger accident safety requirements:

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Estimated Cost Increases to Meet New Hardware Requirements
---------($ in millions)---------

Replace Lot 287 CISS helium bottles-----------	$1.30
Install Centaur engine chilldown instrumentation----------------------------	.02
Remove metal washers in avionics package flex circuit--------------------------------------	.10
Install dual element temperature probes in fill/drain/dump line------------------------	.10
Redesign CONDEC pressure regulator on Centaur for outlet burst capability----------------	.50
Incorporate rotation system pryo pin puller---	.38
Incorporate hydrogen horizontal vent system (oxygen vent under study)------------------	1.30
LOX tank pressure sense line purge orifice change---------------------------------------	.08
Develop removable foam segments for cryogenic valves---------------------------------------	.25
Modify CISS LH_2 dump valve cycling/leak test ground support equipment--------------------	.18
Qualify "D" version Hartman relays in the dual failure tolerant arm/safe sequencer---------	.01
Retrofit/qualify EDU with "D" version Hartman relays---------------------------------------	.10
TOTAL	$4.32

Technical Documentation Review and Analysis

The following provides a breakout of the estimated cost to complete the approved technical documentation review and analysis:

Estimated Cost Increases for Technical Documentation Review and Analysis

-------($ in millions)--------

Centaur/CISS avionics package pedegree/history	$ .28
Redlines/launch commit criteria	.20
Independent safety review analysis	3.50
Fracture control/analysis/compliance	.25
Centaur tank pressure control assumptions/ analysis/software logic	.50
Level II review of safety critical component reliability and quality assurance programs	.20
Place control unit software under level II control	.30
Prepare integrated test plan safety verification tracking for recurring verification	.10
TOTAL	$5.33

As shown above, the independent safety review analysis line item represents $3.5 million of the estimated $5.3 million to complete the technical documentation review and analysis. Teledyne Brown Engineering Company has been tasked to systematically identify and analyze, through fault tree analysis, catastrophic failures within the Centaur system, and failure causes that could result in the loss of the Shuttle and/or its crew. The Director of Flight Support Systems at LeRC determined that this independent analysis was needed to insure that all potential Centaur hardware failures had been identified. A cognizant General Dynamics official stated that in view of the Challenger accident this study is essential.

Under the terms of this contract Teledyne Brown will conduct an independent safety assessment of the Centaur system as it was configured to fly aboard the Shuttle for the May 1986 launch. Hardware changes resulting from ongoing enhancements and/or new requirements will be incorporated as they occur. NASA officials stated that this should not present any problems.

The Teledyne Brown analysis is being done under a level of effort general support contract that ANALEX, a consulting firm staffed by many former NASA employees, has with LeRC. ANALEX, in turn, has subcontracted with Teledyne Brown to conduct this independent analysis. An ANALEX official, a former Chief of the Launch Systems Division at LeRC, stated that contract negotiations were close to being finalized. He estimated the negotiated contract price will be $1.5 million, including an ANALEX fee of $200,000. This official stated that Teledyne Brown is to complete its work by December 1986. He added that a decision to do additional fault tree analysis of the launch ground support equipment and the Centaur-Shuttle interface will be made at a later date. He estimated the cost of the additional analysis would be approximately $2 million.

Engineering Concerns Under Study

The following is a list of engineering studies that LeRC, JSC, and KSC and their contractors identified as necessary to reevaluate safety, examine the basic program direction, and review the Shuttle-Centaur configuration:

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Estimated Cost Increases for Engineering Studies
($ in millions)

Incorporate oxygen horizontal vent system	$ .30
Resolution of water hammer concerns in LOX system	.06
Pneumatic actuated valve control system regulator instability	.10
Jet pulse mixer redesign	3.40
Cryogenic valve acceptance testing with LO_2/LH_2	[illegible]
Redesign/retrofit for CISS helium bottle isolation	[illegible]
Design/retrofit of new control valves in LOX/LH_2 tanking skids	.39
Replace 150 A-H battery with 250 A-H battery	.50
Incorporation of hard wire control for 3 control unit failure case to preclude EVA requirement	1.00
Implementation scheme for the standard switch panel for turn off of the inertial reference unit purge	.08
Hardware/software/operational requirements/ MODS to establish controlled Centaur/Orbiter/ ground environment for all post-abort landing scenarios	.50
Optimum Centaur/CISS fill/drain/dump valve pneumatic actuation system configuration (crosstrap vs. separate)	.83
Definition of current validation of redundant control paths and test program and hardware to verify full scale testing using fluid/ avionic/software systems (JSC and Astronauts want to exercise these redundant systems)	.25
Centaur software to allow dump/tank inert independent of vent inhibits (Astronauts Driven)	.10
Redesign/modifications required to eliminate post landing hydrogen vent through failed open or leaking thermodynamic vent system valves on CISS	.60
Redesign/modifications required to eliminate loss of entry/post landing vent control with failed open vent valve on Centaur	1.25
Procure additional computer control launch system at San Diego and the Eastern Test Range	3.10
Procure additional government supported equipment and special test equipment	.60
TOTAL	$13.90

LeRC officials cautioned that these are "ballpark" estimates and could vary considerably. For example, they stated the $3.4 million for the Jet Pulse Mixer redesign may not be needed upon further evaluation, but the $100,000 included for the pneumatic actuated valve control system regulator instability may be understated because this problem is not fully understood.

Implementation of Major Engineering Changes

NASA officials stated that of the engineering concerns under study, four will have a direct impact on the program's schedule and cost. The following provides a breakout of these four changes under study and the ranges of cost estimates that were provided by program officials during late March 1986.

	Estimated Cost Increases for Major Engineering Changes ------($ in millions)-------
Incorporate oxygen horizontal vent system----	$ 1.3-$2.5
Resolution of water hammer concerns in liquid oxygen system-----------------------	$ 1.2-$3.0
Hardware/software/operational requirements/ made to establish controlled Centaur-Orbiter/ ground environment to All post-landing scenarios---------------------------------	$ 2.0-$6.0
Definition of current validation of redundant control paths and test program and hardware to verify full scale testing using fluid/ avionic/software systems------------------	$10.0-$15.0
TOTAL	$14.5-$26.5

During mid-May, NASA officials stated that the LeRC engineers have developed a proposal for a test article to validate redundant control paths and to verify full scale testing using fluid and avionic software systems. Under the LERC proposal all testing would be done at Complex 36A at KSC. NASA officials stated the LeRC cost estimate of $10 to $15 million includes: modifying Complex 36A; building test software and developing procedures; purchasing permanent commercial tanks; and testing required for the Ulysses launch scheduled for August 1988.

NASA headquarters officials stated they do not know if this test article proposal to be presented by LeRC to the Associate Administrator for Space Flight during the week of May 26, 1986, will satisfy the JSC engineering community. These officials concluded that if JSC accepts this proposal, the "ballpark" estimates to implement these four major engineering changes are probably realistic. However, if JSC demands a full-up test article, the cost estimate to validate redundant control paths and to verify full scale testing would increase from $10-$15 million to approximately $50 million according to NASA and General Dynamics officials. These officials also stated that if JSC required a full-up test article, the Ulysses launch date of August 1988 would be in jeopardy.

Issues Impacting the Shuttle-Centaur Program Schedule

Lack of Agency Direction

Until mid-May, NASA had been operating with an acting Administrator. Also, shortly after the Challenger accident, the Deputy Associate Administrator for Space Flight was replaced. His replacement readily admitted that he has very little knowledge of the Shuttle-Centaur program. He stated that he has spent the majority of his time as the Deputy Administrator responding to Presidential Commission findings and to issues concerning the families of the Challenger crew. He added that since he had assumed his position, NASA's priorities have been to: identify the solid rocket motor problem and take any necessary corrective action through redesign; overcome the filament wound solid rocket booster problem required for most Shuttle launches from Vandenberg; correct the Space Shuttle Main Engine problems and certify these engines at the 109 percent power level; and address the Shuttle-Centaur safety issues. Many cognizant NASA officials stated that no decision would be made concerning the Shuttle-Centaur program until a new Administrator was on board.

The Deputy Associate Administrator for Space Flight stated that hard decisions regarding Shuttle-Centaur safety issues must be addressed in the near term, but declined to say when decisions concerning the program's fate would be made.

Uncertainty of Launch Opportunities

The Challenger accident, the uncertainty of the requirements to be levied by the ongoing Presidential Commission investigation, and the time required to fix all problems identified by this Commission and by NASA internal reviews have indirectly impacted the Shuttle-Centaur program.

The two interplanetary missions have limited launch opportunities. Ulysses can be launched only during a 20-30 day planetary window which occurs every 13 months. Galileo can also be launched during this same window but has one additional launch opportunity using a different type of interplanetary trajectory. Once a decision is made as to when the Shuttle can return to normal operation, these two interplanetary mission must vie with high priority DOD missions for a position on the flight manifest.

Initially NASA believed the Shuttle would be out of operation for only 13 months. Under that assumption Galileo was scheduled to be launched during December 1987 and Ulysses was scheduled for August 1988. NASA has recently announced that it does not plan for the Shuttle to be operational prior to July 1987. Under this scenario, which has not yet been announced as NASA's official position, Ulysses is scheduled to be launched in August 1988, but Galileo has slipped from December 1987 to January 1989. Some NASA officials believe the Shuttle will be out of operation longer than the 18 months now used for planning purposes. One NASA official at the Jet Propulsion Laboratory, who is in the preliminary stages of a study concerning alternate transportation for planetary missions, is using 2.5 years as a downtime assumption for the shuttle. If these NASA officials are correct, these two interplanetary flights will be further delayed.

Increased Emphasis on Safety

The Centaur was a significant flight safety issue prior to the Challenger accident and is being viewed with increased conservatism in the wake of the Mission 51-L explosion. The views expressed by cognizant aerospace officials over placement of this oxygen/hydrogen stage in the shuttle payload bay varied from those who believe the Centaur as a shuttle upper stage should be cancelled to those who believe the Centaur as a shuttle upper stage can be made safe enough with the successful completion of additional testing. These views follow:

JSC Management Officials

Some management officials at JSC stated the risks and potential consequences of flying the Centaur in the orbiter bay are too great. They stated that if an accident caused by the Centaur should occur, the entire space program would be in jeopardy. These officials added that when one weighs the known risks against the potential consequences, the Shuttle-Centaur program should be cancelled.

These officials stated that if a decision is made to continue this program, all redundant control paths of fluids, avionics, and software systems must be fully tested and overall margin designs demonstrated. They estimated that this full-up test article could take from 2 1/2 to 3 years to develop (includes test time). These officials concluded that the time and money required to bring the Shuttle-Centaur program within acceptable risk limits are too great when compared with other NASA program requirements.

Galileo and Ulysses Interplanetary Crews

Crew members for the two interplanetary flights stated that an acceptable level of risk can be achieved given enough time and money. They stated that in retrospect, a full-up test article should have been a requirement from the outset of the program. The flight crews strongly believe that additional testing needs to be done, especially the fluid systems and the redundant paths of all components. Both crews stated that they are willing to rely on the professional judgement of the Engineering Directorate at the JSC to determine the level of testing required. They stated that a full-up test article would take from 2 to 3 years for completion. Both crews strongly believe that the two interplanetary missions can be successfully launched because the preparations of these two launches are being carefully scrutinized.

Engineering Communities at JSC and at LeRC

The Director of Research and Engineering at JSC stated that until the fatal Challenger accident the engineering community at JSC had not been as actively involved in the Shuttle-Centaur program as it currently is. He attributed this lack of involvement to the fact that the Centaur was viewed by NASA as a Shuttle payload managed by the LeRC rather than a Shuttle vehicle element with unique safety implications. Since the Challenger accident, the JSC safety community has become much more involved and has raised many safety related issues, which it now thinks should be addressed during the time the shuttle is out of operation. The Director for Research and Engineering added that this down time provides a good opportunity to make safety enhancements to the program.

The Director of Research and Engineering and the Director of Propulsion and Power Division at JSC believe that the Centaur can be made safe enough to fly aboard the Shuttle. These engineers agreed that testing is a must. They added that the more testing that is done, the more the risk factor is reduced and one can only hope that risk is reduced to an acceptable level. These two engineers stated that the ideal technical solution would be to have a full-up test article, which would take about 2 years to build and to require about 6 months of testing. They agreed that economics and time may be constraints that would prohibit the building of a full-up test article.

These JSC engineers stated there is a possibility that testing may be accomplished using the flight hardware from either Galileo or the Ulysses Centaur. They stated that the Shuttle-Centaur Program Management at the LeRC is preparing such a proposal to be presented by late May 1986. However, these JSC engineers cautioned that the tanks from the flight articles are not strong enough to withstand the numerous pressure changes inflicted during testing.

The engineering community at LeRC stated it believes the testing requirements can be met by using one of the flight articles. These engineers stated that either the Galileo or Ulysses Centaur could be fully tested with the use of special software. They said this would simulate full-up testing except for the outflowing of propellants. The engineering community at LeRC strongly disagrees with the requirement of a full-up test article. These engineers said that the JSC community wants a full-up test article that would test the system beyond inflight requirements. The engineering communities at JSC and LeRC agree that a decision must be made soon as to what depth of testing NASA will officially endorse, if the Galileo mission is to be ready for launch by late 1987.

Aerospace Safety Advisory Panel

Two members of the Aerospace Safety Advisory Panel, identified by NASA officials as the most knowledgeable concerning Shuttle-Centaur issues, provided conflicting views concerning the fate of the program. They did, however, agree that the panel did not discuss this issue in depth at a recent fact finding session and that the panel has no official position concerning the continuance of the Shuttle-Centaur program.

One panel member stated that he is able to address the Shuttle-Centaur concerns only from a philosophical perspective, since he does not have the technical expertise. He stated that flying the Centaur from the orbiter bay is adding hazards that should not be risked unless there is no other way to launch these heavy payloads. He further stated that before a Shuttle-Centaur is launched, it must be fully demonstrated that the system is safer than has been shown to date. He concluded that the Centaur is a "single stringed" machine which was designed and developed to be launched from an expendable launch vehicle. If the intent were to integrate the Centaur with the orbiter, it should have been designed and developed parallel with the orbiter.

The panel member who could provide a technical perspective stated that the cryogenic fuels aboard the Centaur can be handled technically. He stated that with all the safety precautions currently planned, the level of risk is manageable. He further stated that the Aerospace Safety Advisory Panel will continue to follow the Centaur issues, but unless specifically requested by NASA management the panel will do no in-depth analysis of this program.

Department of Defense

Officials from the Air Force Space Launch and Control Division stated they have not become involved with the safety related Shuttle-Centaur issues; they have relied on NASA to address these issues. These officials stated that DOD currently has fourteen payloads manifested which require the Centaur upper stage. Seven of these missions are scheduled as Shuttle-Centaur launches. These officials stated that DOD is dependent upon the Shuttle-Centaur program because, along with the Complementary Expendable Launch Vehicles under production, the shuttle provides dual compatibility and an assured access to space.

Other Related Issues

Although not directly related to Centaur system hardware, other issues could have an effect on the success of the two interplanetary missions. These issues could also significantly impact NASA costs, although not directly related to the Centaur line item.

Radioisotope Thermoelectric Generators (RTG's)

RTG's, fueled by radioactive plutonium-238, provide a source of heat to produce electrical energy for planetary missions where solar conversion power supplies are impractical. Since 1961, the United States has used RTG's to power unmanned spacecraft systems in 22 missions.

The Ulysses spacecraft is equipped with one RTG and the Galileo with two. The use of RTG's as a power source for these Shuttle-Centaur payloads has become a safety issue since the Challenger accident. Many concerns have been raised about the probability of a plutonium release during various launch accident scenarios. The Interagency Nuclear Safety Review Panel, the group responsible for evaluating the nuclear risks associated with launching space vehicles with nuclear systems aboard, is reviewing the results of the ongoing Challenger accident investigation to determine its implications upon the Galileo and Ulysses nuclear risk assessments. Preliminary analyses have shown that the resulting pressure from the Challenger explosion was only about 200 to 400 pounds per square inch (psi) whereas the RTG's are designed to withstand 2200 psi overpressure. Also preliminary analysis has shown that the Challenger explosion appears not to have generated enough energy to produce high-velocity fragments which could violate the integrity of the RTG and cause a release of radioactive material.

NASA officials stated that evidence to date supports launching in the current configuration without RTG shields, but because this is such an emotional issue with potential political overtones and because the safety review process for approving launches of spacecraft utilizing radioactive sources is quite lengthy, they have opted to plan for the use of RTG shielding as a worse case scenario. NASA officials stated there would not be enough time to design, develop, and fabricate the RTG shields if they do not start soon.

The Galileo Project Manager stated that a preliminary design review for shielding is planned for September 1986. This official stated that a decision could be made concerning the requirement for RTG shielding by late 1986 or early 1987. If the launches are approved in current configuration, the shield requirement will be terminated. JPL officials estimate that shields for the two interplanetaries would cost between $15-$20 million.

The requirement for RTG shielding would increase the Shuttle lift requirement by approximately 2100 pounds. The Galileo Project Manager stated that the Galileo lift requirement including the RTG shields can be met during a Delta-Vega launch window with the Space Shuttle Main Engines (SSME) operating at the 104 percent power level. He stated that a 109 percent SSME power level would only be required to launch Galileo using a direct launch window. He added that there are no plans to launch Galileo using a direct launch window. The Ulysses lift requirement can easily be met using a direct launch window at a 104 percent SSME operating power level.

Program Managers for the Galileo and Ulysses missions stated once the RTG's are assembled, they begin to lose from 7 to 10 watts each year. The Ulysses Project Manager stated that by 1988 the number of watts lost could affect the European Space Agency portion of the Ulysses mission, and the entire mission would be seriously degraded by 1989. This official stated a Ulysses launch during 1990 would require the RTG to be replaced. The Galileo Project Manager stated the two RTG's aboard the Galileo would be serviceable through a 1990 Delta-Vega launch window or a 1992 direct launch. This is because a Delta-Vega launch would take the Galileo satellite two years longer to reach Jupiter than a direct launch. These officials stated there is a 3 year lead time required for RTG replacement. An RTG costs from $30-$35 million to be completely replaced. The life of an RTG can, however, be extended approximately 2 years by replacing one-third of its modules. Replacing one-third of the modules costs approximately $20 million.

Centaur Related Orbiter Modifications

Since the Challenger accident, NASA has taken a hard look at all single failure and redundant element failures which could cause a loss of life and/or vehicle. This has resulted in the identification of many orbiter modifications, some of which are driven by Centaur related issues. For example, concerns have been raised about the venting of gaseous hydrogen that would cause overheating of the orbiter tail section. This could result in a high probability of significant orbiter damage due to vent flame after an abort landing.

This modification, which requires the removal of the tail section of the orbiter, is a long lead item. NASA has obtained approval from the House Appropriations Committee to spend up to $700,000 for preliminary design so work can begin on the two orbiters while the Space Shuttle is out of operation. NASA has estimated that the modification of the hydrogen venting system will cost approximately $10 million.

NASA
National Aeronautics and
Space Administration

Budget Estimates

FISCAL YEAR 1987

Volume I

Agency Summary

Research and Development

**Space Flight, Control and
Data Communications**

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1987 ESTIMATES

VOLUME I

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THIS DOCUMENT DOES NOT REFLECT: (1) THE FY 1986 REDUCTIONS THAT ARE LIKELY TO RESULT UNDER THE BALANCED BUDGET AND EMERGENCY DEFICIT CONTROL ACT OF 1985; OR (2) THE EFFECTS RESULTING FROM THE LOSS OF THE CHALLENGER AND CREW ON JANUARY 28, 1986. PROPOSED CHANGES IN PROGRAM PLANS AND BUDGET ESTIMATES WILL BE TRANSMITTED LATER.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1987 ESTIMATES

GENERAL STATEMENT

The National Aeronautics and Space Administration conducts space and aeronautical activities for peaceful purposes and the benefit of all people. NASA's activities are designed to enhance United States leadership in aeronautics and in space research, exploration and utilization. More specifically, the objectives of NASA's activities are to:

-- Make the Space Transportation System fully operational and cost effective;

-- Move forward toward the establishment of a permanently manned Space Station;

-- Conduct an effective and productive program of aeronautical research and technology which will contribute materially to the enduring preeminence of the United States in aviation;

-- Conduct an effective and productive Space and Earth Sciences program which expands human knowledge of the Earth, its environment, the solar system and the universe;

-- Conduct effective and productive space applications and technology programs which contribute materially to our nation's current and future leadership in space; and

-- Enhance opportunities for U.S. private sector involvement in civil space and space-related activities

The NASA FY 1987 budget recommendation of $7,694 million provides for a deliberately paced program of flight projects and ground-based activities to make progress toward these objectives.

Space program elements in FY 1987 involve:

o Definition and technology effort and initial development efforts on a permanently manned Space Station, the next major step in exploration and utilization of space and a key element in continued U.S. leadership in space. The ability to function routinely in space onboard the Space Station will provide countless opportunities for experimenting in the known sciences as well as in those still to be discovered. The Space Station will be a multi-purpose, international facility for scientific and technical research and for unique commercial applications, broadening the horizons of all those who participate. Definition and preliminary design contracts as well as advanced technology development will continue in FY 1986 in preparation for initiation of development efforts in FY 1987.

o Expanded use of the Space Shuttle and other elements of the Space Transportation System capitalizing on its demonstrated capabilities to place satellites in orbit, to retrieve and repair satellites, and to conduct experiments and make observations using the Shuttle and the Spacelab. The FY 1987 program will provide for the procurement of the hardware, mission integration and training, ground processing and flight operations of the Space Shuttle. Seventeen Shuttle flights during 1987 will carry payloads for NASA, Department of Defense and domestic commercial and international users of space. Additional Spacelab flights will capitalize on the success of the initial missions as this unique capability is exploited for space research and applications missions. The first uses of the planetary version of the Centaur Upper Stage will occur in 1986 for the Galileo and Ulysses missions adding this high energy upper stage to the STS system. The initial launch from the Vandenberg launch site in 1986 using the first set of lightweight filament wound cases for the Solid Rocket Booster will also greatly expand the versatility of the STS system. In 1987, work will continue on the the Space Shuttle main engine to improve the operating margins, reliability and maintainability of the present configuration and development efforts will be continued on a reusable orbital maneuvering vehicle to extend operational on-orbit capabilities beyond the range of the orbiter.

o Space Science and Applications programs which are directed toward increasing our knowledge and understanding of life processes, the Earth and its space environment, the planets, the Sun, the stars, and the universe, as well as conducting a carefully coordinated and logically phased set of research and development activities that demonstrate and transfer the applications of space-related technology which can be effectively used for down-to-Earth practical benefits. The FY 1987 program provides for operations and data analysis activities in support of Galileo, Ulysses and Hubble Space Telescope missions which will be launched in 1986 and for research and analysis activities in physics and astronomy, planetary, life sciences, and space applications. NASA will use the ASTRO mission telescopes, to be carried aboard the Shuttle in early 1986, as a major element of its participation in the international program for the observation of Halley's Comet. Efforts will also continue on approved flight programs which include: the Gamma Ray Observatory, which will study the total range of gamma ray energies, the most energetic electromagnetic radiation known; the Upper Atmosphere Research Satellite mission, which will make integrated measurements of energy inputs, temperature, chemical constituents and winds; the Magellan mission (formerly Venus Radar Mapper) which will address the fundamental questions regarding the origin and evolution of the planet Venus by obtaining global radar imagery of the planet; the Mars Observer mission, which will provide geoscience and climatology mapping of Mars and extend and complement the data acquired by the Mariner and Viking missions; the continued develoment of the Scatterometer, which will be flown on the Navy's N-Ross mission; and continued development of the Explorer missions and the Spacelab and Tethered Satellite System payloads. Development will be initiated on the Ocean Topography Experiment, a joint cooperative effort with the French to develop and launch a new oceaning-observing satellite and to use the data obtained to develop an improved understanding of the ocean circulation and its influence on our global environment. These major development efforts are integrated with and based on a broad scale program of research and analysis to define future potential missions and to develop and demonstrate ground-based application of the data acquired by remote sensing techniques.

o Space research and technology activities to advance the technology base which provides new concepts, materials, components, devices, software and subsystems for use in United States civil and military space activities. This research emphasizes the longer range aspects of generic research and technology development in transportation, spacecraft and platform systems which are crucial to future United States leadership in space.

The Aeronautical research and technology program contributes materially to the enduring preeminence of U.S. civil and military aviation by: (1) conducting disciplinary and systems research at the leading edge of technology in those areas critical to the continued superiority of U.S. aircraft; (2) maintaining the research centers in positions of excellence in facilities and technical staff; (3) assuring timely transfer of research results to the U.S. aeronautical industry; (4) assuring appropriate involvement of universities and industry; and (5) providing aeronautical development support to other government agencies and U.S. industry. Conducted well in advance of and independent of specific applications, the Aeronautical research and technology program includes both fundamental research in the aeronautical disciplines and systems research applicable to general classes of advanced military and civil aircraft. The program involves participation by aeronautical manufacturers to ensure that the technology is compatible with practical design considerations and can be successfully transferred into application in new and better aircraft, systems and components.

Transatmospheric research and technology efforts to accelerate the development of a critical technologies data base that may enable a potential new class of vehicles in the future capable of flight to orbit and/or hypersonic cruise. Possible opportunities in this regime include launch vehicles, hypersonic transports, and military applications.

Resources Summary
The budget authority recommended for FY 1987 totals $7,694.4 million with estimated outlays of $7,641.3 million and civil service staffing level of 21,800 full-time equivalent workyears.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

	Budget Plan		
	1985	1986	1987
RESEARCH AND DEVELOPMENT	2,468,100	2,756,800	3,003,100
Space Station	155,500	205,000	410,000
Space Transportation Capability Development	391,400	437,000	465,500
Space Science and Applications	1,404,500	1,548,500	1,464,000
Technology Utilization	9,500	11,100	13,300
Commercial Use of Space	(7,600)[a]	17,000	32,000
Aeronautical Research and Technology	342,400	354,000	376,000
Transatmospheric Research and Technology	---	---	45,000
Space Research and Technology	150,000	168,000	180,200
Tracking and Data Advanced Systems	14,800	16,200	17,100
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	3,594,200	3,397,900	3,069,000
Shuttle Production and Operational Capability	1,484,500	971,600	745,400
Space Transportation Operations	1,314,000	1,725,000	1,524,700
Space & Ground Networks, Comm. and Data Systems	795,700	701,300	798,900
CONSTRUCTION OF FACILITIES	157,600	139,300	181,300
RESEARCH AND PROGRAM MANAGEMENT	1,331,780	1,362,000	1,441,000
TOTAL	7,551,680	7,656,000	7,694,400
OUTLAYS	7,317,741	7,587,203	7,641,347

[a] In FY 1985, funded as part of the Office of Space Station ($.4 million), Office of Space Flight ($.5 million), Office of Space Science and Applications ($3.5 million), Office of Aeronautics and Space Technology ($1.2 million), and Office of Space Tracking and Data Systems ($2.0 million).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

SPACE STATION

- o Establish a permanently manned space station:
  - The next logical step in U.S. leadership in space
  - Built upon the operational capabilities of the Space Shuttle
  - Conducive to user community
  - Orbital activities begin in the next decade
- o Conclude a thoroughly detailed front-end definition including:
  - Engineering design by industrial contractors
  - Subsystem advanced development and tests in dedicated test beds
  - Early flight experiments on the Shuttle to prove system feasibility
  - Continued trade studies for system optimization
- o Initiate development of a multi-purpose facility involving both manned and unmanned elements to facilitate:
  - Essential scientific and technical research
  - Unique commercial activities
  - More efficient operational tasks in space such as:
    - Satellite servicing
    - Assembly and servicing of platforms
    - Placement of spacecraft into higher orbits
  - Extensive national and international user community participation through:
    - Simplified user interfaces
    - Capability for on-orbit crew maintenance
    - Operational autonomy to achieve effective long-term performance
  - Staging for potential future national programs such as:
    - Manned missions to the Moon or planets
    - Unmanned scientific probes and sample returns

MAJOR FLIGHT ACTIVITY

	Fiscal Years						
	1985	1986	1987	1988	1989	1990	1991
Flight Experiments on Space Shuttle.................		Δ					

BUDGET PLAN (millions of dollars)	FY 1985	FY 1986	FY 1987
Utilization	9.3	11.1	15.0
Advanced Development	50.1	70.8	83.0
Program Management/Integration	57.5	60.0	57.0
Operational Readiness	2.9	5.3	17.0
Systems Definition	35.7	57.8	88.0
Systems Development	---	---	150.0
Total	155.5	205.0	410.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT

- Proceed with development of the capabilities to enhance the space transportation system through pursuit of:
    - Manned orbital experiments using Shuttle and Spacelab
    - First use of Centaur upper stage to place payloads into deep space and in geosynchronous orbits
    - Identification of future space programs and new technology to reduce program risks
    - Orbital placement, servicing and retrieval of automated satellites
    - Orbital maneuvering vehicle to extend operational on-orbit capabilities range
- Development of United States-Italian Tethered Satellite System
- Maintain engineering, scientific and technical support capability
- Development of operational equipment to support payload pre- and post-launch processing and on-orbit operations

MAJOR FLIGHT ACTIVITY

	Fiscal Years						
	1985	1986	1987	1988	1989	1990	1991
Spacelab (Operational flights)	△						
Tethered Satellite System					△		
Orbital Maneuvering Vehicles							△

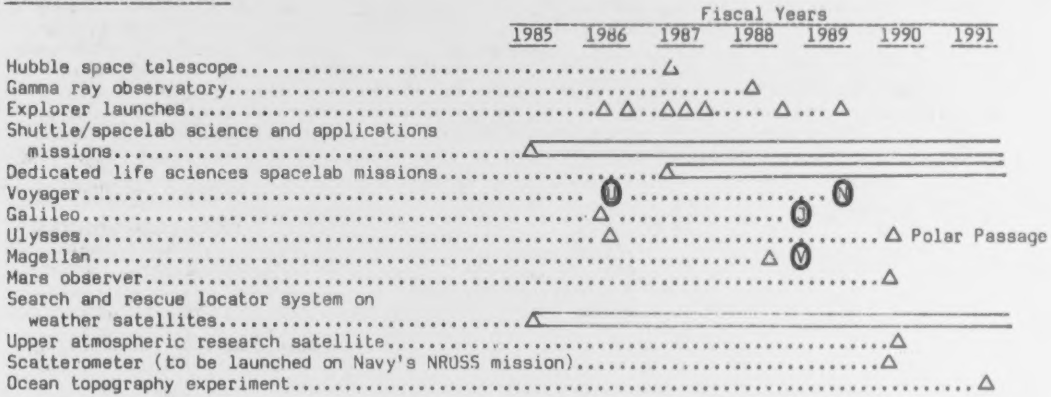
BUDGET PLAN (millions of dollars)	FY 1985	FY 1986	FY 1987
Space Transportation Capability Development	391.4	437.0	465.5

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

SPACE SCIENCE AND APPLICATIONS

- o Increase our understanding of the Earth and its environment, the solar system, and the universe through a balanced program of space exploration missions and ground-based investigations;
- o Utilize the space environment for research in the biomedical, biological, and bioinstrumentation fields;
- o Exploit the knowledge gained from current and completed program efforts by thorough analysis and interpretation of the scientific data obtained; and
- o Develop and demonstrate practical uses of space and space-derived technology

MAJOR FLIGHT ACTIVITY



BUDGET PLAN (millions of dollars)	FY 1985	FY 1986	FY 1987
Physics and Astronomy	677.2	607.1	539.4
Life Sciences	62.3	69.9	74.7
Planetary Exploration	290.9	352.8	323.3
Space Applications	374.1	518.7	526.6
Total Space Science and Applications	1404.5	1548.5	1464.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

AERONAUTICAL RESEARCH AND TECHNOLOGY

- o Conduct the fundamental research and technology in the aeronautical disciplines and systems research applicable to general classes of advanced civil and military aircraft to:
  - Improve performance
  - Reduce costs
  - Increase safety
  - Reduce energy requirements
  - Decrease environmental effects

- o Develop and sustain a strong research and technology base in:
  - Fluid and thermal physics
  - Applied aerodynamics
  - Materials and structures
  - Controls and guidance
  - Human factors
  - Information sciences
  - Propulsion and power
  - Flight systems
  - Systems analysis

- o Conduct focused systems technology to evaluate the technical feasibility of advances or concepts:
  - Numerical aerodynamic simulation for complex aerospace computational problems
  - Technology for next generation rotorcraft including X-Wing and advanced tilt-rotor technology
  - Turbine engine hot section technology for higher performance and longer lasting engines
  - High-performance flight research
  - Advanced rotorcraft technology and flight research
  - General aviation/commuter engine technology for better performance and efficiencies
  - Advanced turboprop systems for faster, more fuel-efficient transport and commuter aircraft
  - Ceramics for turbine engines for high operating temperatures
  - Oblique wing technology for aerodynamic efficiency over transonic speeds

- o Maintain expertise and operate significant national facilities to support research and technology:
  - Research and test facilities
  - Simulation facilities
  - Wind tunnels

BUDGET PLAN (millions of dollars)	FY 1985	FY 1986	FY 1987
Aeronautical Research and Technology	342.4	354.0	376.0

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY

o Develop the critical technologies data base to enable the United States to make a future decision on the flight research phase of a transatmospheric vehicle by conducting research and technology development in:

- Efficient, high thrust, airbreathing propulsion systems
- Reusable and durable thermal structures minimum weight, high performance, propulsion/airframe integration

BUDGET PLAN (millions of dollars)

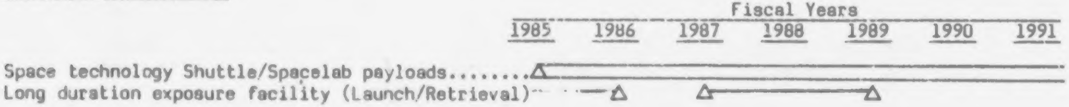
	FY 1985	FY 1986	FY 1987
Transatmospheric Research and Technology	---	---	45.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
RESEARCH AND DEVELOPMENT

SPACE RESEARCH AND TECHNOLOGY

- Provide a technology base essential to future United States leadership in space by:
  - Improving performance and effectiveness
  - Reducing cost and risk
  - Increasing reliability
  - Developing technological options
- Achieve these objectives, by means of ground and space-based research and technology activities, through advances in the technology areas of:
  - Aerothermodynamics
  - Materials and structures
  - Space energy conversion
  - Propulsion
  - Space data and communications
  - Information sciences
  - Controls and guidance
  - Human factors
  - Flight systems
  - Systems analysis
  - Automation and robotics

MAJOR FLIGHT ACTIVITY



BUDGET PLAN (millions of dollars)	FY 1985	FY 1986	FY 1987
Space Research and Technology	150.0	168.0	180.2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY/SPACE TRANSPORTATION OPERATIONS

- Continue with the operational establishment of a versatile and cost-effective space transportation system to provide for:
    - Operating a national fleet of four Space Shuttle orbiters
    - Completing the development of an operationally cost effective main engine with adequate safety margins
    - Ground support equipment, launch site equipment and manpower to support launch and landing operations
    - External tanks and solid rocket boosters and the manufacturing tooling/equipment supporting their production
    - Establishing logistics support capability to provision spares, repair and overhaul flight hardware
    - Provision of capability for training astronauts, launch and flight operation personnel
- Seventeen operational flight missions in FY 1987 building to a flight rate of 24 per year by FY 1989
- Continued improvement of Shuttle performance capability
- Support to first Vandenberg Air Force Base flight
- Implementation of improvements to make space transportation more economical and cost effective to all users

MAJOR FLIGHT ACTIVITY

	Fiscal Years						
	1985	1986	1987	1988	1989	1990	1991
Space Shuttle: Operational flights	8	14	17	18	24	24	24

BUDGET PLAN (millions of dollars)	FY 1985	FY 1986	FY 1987
Shuttle Production and Operational Capability	1,484.5	971.6	745.4
Space Transportation Operations	1,314.0	1,725.0	1,524.7
	2,798.5	2,696.6	2,270.1

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROGRAM HIGHLIGHTS
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

SPACE AND GROUND NETWORKS, COMMUNICATION AND DATA SYSTEMS

- Tracking and Data Acquisition using Space and Ground Network interconnected with highly reliable communications to provide support to:
  - Shuttle operational flights
  - Automated Earth orbiting missions - supports applications and scientific spacecraft including the Nimbus, Landsat, International Ultraviolet Explorer, International Sun-Earth Explorer, Solar Maximum Mission, Dynamics Explorer, Solar Mesosphere Explorer, Earth Radiation Budget Satellite, and Active Magnetospheric Particle Tracer Explorer.
  - Planetary missions - support will continue for Pioneers-10 and -11, Pioneer Venus, and Voyagers-1 and -2, as well as limited support for the earlier Pioneer missions
  - Upcoming missions which will include Hubble Space Telescope, Galileo and Ulysses
  - Sounding rockets
  - Aeronautical flight research program
- The Tracking and Data Relay Satellite System (TDRSS) will replace most ground stations in providing tracking, command and telemetry services to all low-Earth orbital missions. The first spacecraft was launched in April 1983, the second is scheduled to be launched in January 1986 and the third launch is planned for the last half of 1986.

MAJOR FLIGHT ACTIVITY

	Fiscal Years						
	1985	1986	1987	1988	1989	1990	1991
Tracking and Data Relay Satellite (Backup satellites available)		△* △					

BUDGET PLAN (millions of dollars)	FY 1985	FY 1986	FY 1987
Space & Ground Network, Comm., and Data Systems	795.7	701.3	798.9

*Mission failed January 28, 1986

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1987 ESTIMATES

SUMMARY RECONCILIATION OF APPROPRIATIONS TO BUDGET PLANS
(Thousands of Dollars)

	Total	Research and Development	Space Flight, Control and Data Comm.	Construction of Facilities	Research and Program Management
Fiscal Year 1985					
Appropriation PL 98-371............	7,495,900	2,417,100	3,601,800	150,000	1,317,000
Reappropriation, PL 98-371.........	5,500	5,500	---	---	---
Transfer Between Accounts..........	---	---	-7,600	+7,600	---
Supplemental Appropriation, PL 99-88.........................	65,800	45,500	---	---	21,300
Rescission.........................	-6,000	---	---	---	-6,000
Lapse..............................	-520	---	---	---	-520
Total Budget Plan................	7,551,680	2,468,100	3,594,200	157,600	1,331,780
Fiscal Year 1986					
Appropriation, P.L. 99-160.........	7,656,000	2,756,800	3,397,900	139,300	1,362,000
Fiscal Year 1987					
Appropriation Request/Budget Plan..	7,694,400	3,003,100	3,069,000	181,300	1,441,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

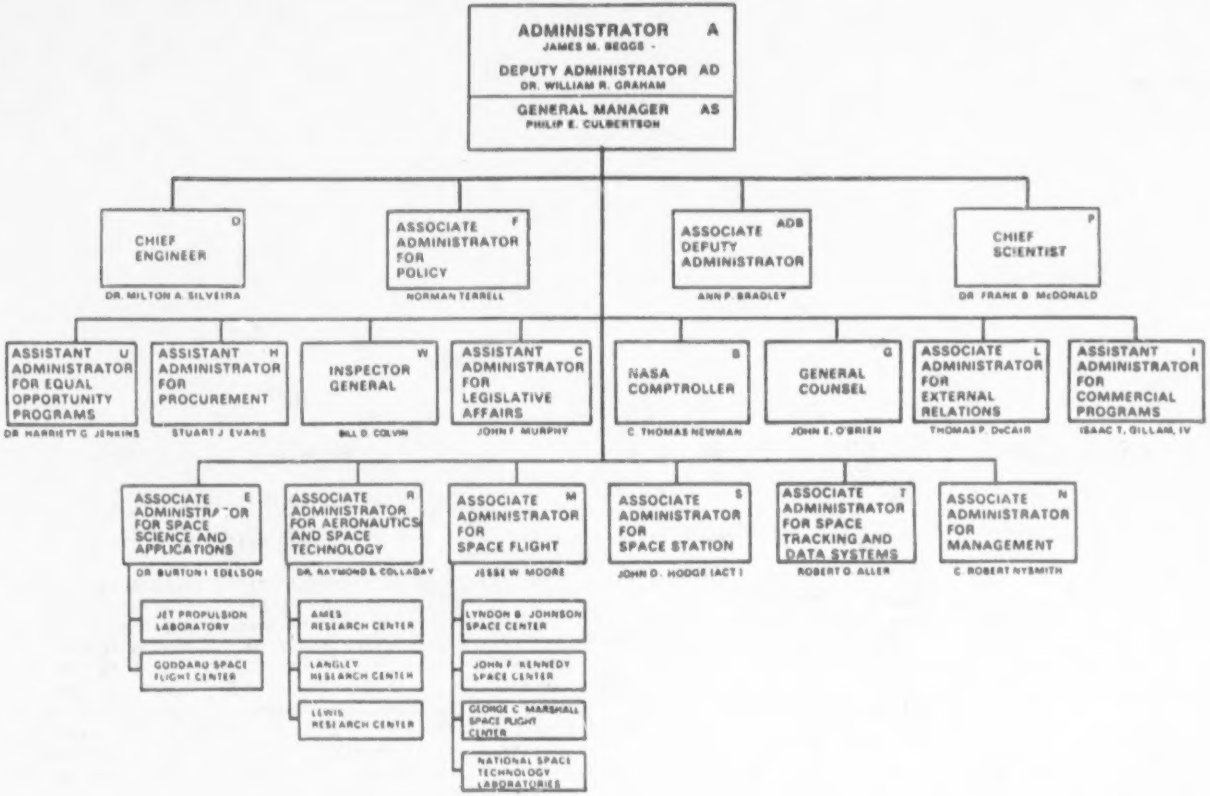
FISCAL YEAR 1987 ESTIMATES

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION
(Millions of Dollars)

	Total			Space Flight Control and Data Communications			Research and Development			Construction of Facilities			Research and Program Management		
	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987	1985	1986	1987
Johnson Space Center.........	1,617,341	1,410,066	1,132,233	1,159,650	918,900	560,500	239,680	280,079	339,623	3,200	1,100	14,000	214,811	209,987	218,110
Kennedy Space Center.........	650,192	692,815	760,492	383,100	407,200	485,800	45,704	69,915	63,196	36,900	21,000	3,400	184,488	194,700	208,096
Marshall Space Flight Center	1,922,920	1,951,033	1,811,551	1,223,467	1,258,200	1,087,700	499,772	486,238	517,904	1,400	6,500	2,100	198,069	200,095	203,847
National Space Technology Laboratories..............	31,117	33,168	32,218	6,300	8,300	8,600	10,848	11,461	12,165	3,300	2,500	—	10,669	10,907	11,453
Goddard Space Flight Center.	1,029,214	1,025,124	1,060,479	431,146	366,600	378,400	399,011	450,794	459,741	2,200	3,800	8,000	196,857	203,930	214,338
Jet Propulsion Laboratory...	511,895	580,691	626,545	111,002	122,500	129,700	388,693	449,291	484,445	12,200	8,900	12,400	—	—	—
Ames Research Center.........	363,522	388,253	443,336	12,345	15,800	14,800	217,287	239,555	267,723	13,600	8,200	26,900	120,290	124,698	133,913
Langley Research Center......	337,016	332,910	388,592	100	100	100	175,994	177,881	221,759	13,800	4,900	11,700	147,122	150,029	155,033
Lewis Research Center........	452,178	469,024	358,177	3,400	3,000	500	311,395	323,047	201,557	—	—	5,800	137,383	142,977	150,320
Inspector General............	5,225	5,511	5,494	—	—	—	—	—	—	—	—	—	5,225	5,511	5,494
Headquarters.................	605,252	739,005	1,026,783	263,670	297,300	402,900	179,716	268,539	434,987	45,000	54,000	61,000	116,866	119,166	127,896
Agencywide Activities.......	—	—	12,500	—	—	—	—	—	—	—	—	—	—	—	12,500
Undistributed Construction of Facilities:															
Various Locations.........	13,800	17,400	22,000	—	—	—	—	—	—	13,800	17,400	22,000	—	—	—
Facility Planning and Design..............	12,000	11,000	14,000	—	—	—	—	—	—	12,000	11,000	14,000	—	—	—
Total Budget Plan........	7,551,680	7,656,000	7,694,400	3,594,200	3,397,900	3,069,000	2,468,100	2,756,800	3,003,100	157,600	139,300	181,300	1,331,780	1,362,000	1,441,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SUMMARY OF PERMANENT CIVIL SERVICE WORKYEARS BY INSTALLATION
FISCAL YEAR 1987 ESTIMATES

	FY 1985	FY 1986	FY 1987
Johnson Space Center	3,247	3,252	3,253
Kennedy Space Center	2,064	2,035	2,030
Marshall Space Flight Center	3,263	3,229	3,234
National Space Technology Laboratories	114	119	119
Goddard Space Flight Center	3,559	3,576	3,576
Ames Research Center	2,044	2,029	2,029
Langley Research Center	2,824	2,812	2,812
Lewis Research Center	2,647	2,655	2,655
Headquarters	1,267	1,242	1,242
Inspector General	94	97	97
Subtotal, Full-Time Permanent	21,123	21,046	21,047
Other Then Full-Time Permanent	870	754	753
Total, Ceiling Controlled Civil Service	21,993	21,800	21,800


ADMINISTRATOR A
JAMES M. BEGGS
DEPUTY ADMINISTRATOR AD
DR. WILLIAM R. GRAHAM
GENERAL MANAGER AS
PHILIP E. CULBERTSON
CHIEF ENGINEER D
DR. MILTON A. SILVEIRA
ASSOCIATE ADMINISTRATOR FOR POLICY F
NORMAN TERRELL
ASSOCIATE DEPUTY ADMINISTRATOR ADB
ANN P. BRADLEY
CHIEF SCIENTIST P
DR. FRANK B. McDONALD
ASSISTANT ADMINISTRATOR FOR EQUAL OPPORTUNITY PROGRAMS U
DR. HARRIETT G. JENKINS
ASSISTANT ADMINISTRATOR FOR PROCUREMENT H
STUART J. EVANS
INSPECTOR GENERAL W
BILL D. COLVIN
ASSISTANT ADMINISTRATOR FOR LEGISLATIVE AFFAIRS C
JOHN F. MURPHY
NASA COMPTROLLER B
C. THOMAS NEWMAN
GENERAL COUNSEL G
JOHN E. O'BRIEN
ASSOCIATE ADMINISTRATOR FOR EXTERNAL RELATIONS L
THOMAS P. DeCAIR
ASSISTANT ADMINISTRATOR FOR COMMERCIAL PROGRAMS I
ISAAC T. GILLAM, IV
ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS E
DR. BURTON I. EDELSON
JET PROPULSION LABORATORY
GODDARD SPACE FLIGHT CENTER
ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY R
DR. RAYMOND S. COLLADAY
AMES RESEARCH CENTER
LANGLEY RESEARCH CENTER
LEWIS RESEARCH CENTER
ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT M
JESSE W. MOORE
LYNDON B. JOHNSON SPACE CENTER
JOHN F. KENNEDY SPACE CENTER
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL SPACE TECHNOLOGY LABORATORIES
ASSOCIATE ADMINISTRATOR FOR SPACE STATION S
JOHN D. HODGE (ACT.)
ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING AND DATA SYSTEMS T
ROBERT O. ALLER
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT N
C. ROBERT NYSMITH

NATIONAL AERONATUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

GENERAL STATEMENT

The objectives of the National Aeronautics and Space Administration program of research and development are to extend our knowledge of the Earth, its space environment, and the universe; to expand the technology for practical applications of space technology; to develop and improve manned and unmanned space vehicles; and to assure continued development of the long-term aeronautics and space research and technology necessary to accomplish national goals. These objectives are achieved through the following elements:

SPACE STATION: A program to develop a United States space station to continue the Nation's leadership in space and to provide for enhancement of science and applications programs and to further the commercial utilization of space while stimulating advanced technologies.

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT: A program to provide for the development and use of capabilities related to the Space Shuttle. The principal areas of activity in Space Transportation Capability Development are efforts related to the development and flight certification of the jointly developed U.S./Italy Tethered Satellite System, development of the Orbital Maneuvering Vehicle, development and operations of the Spacelab systems, the development and procurement of upper stages that place satellites in high altitude orbits, the engineering and technical base support at NASA centers, payload operations and support equipment, and advanced programs study and evaluation efforts.

SPACE SCIENCE AND APPLICATIONS: A program using space systems, supported by ground-based and airborne observations, (1) to conduct a broad spectrum of scientific investigations to advance our knowledge of the Earth and its space environment, the Sun, the planets, interplanetary and interstellar space, the stars of our galaxy and the universe; and (2) to identify and develop the technology for the useful applications of space techniques in the areas of advanced communications satellite systems technology; materials processing research and experimentation; and remote sensing to acquire information which will assist in the solution of Earth resources and environmental problems.

TECHNOLOGY UTILIZATION: The program includes activities to accelerate the dissemination to both the public and the private sectors of advances achieved in NASA's research, technology, and development programs.

COMMERCIAL USE OF SPACE: A program to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology, space-based research and development.

AERONAUTICS AND SPACE TECHNOLOGY: A program to conduct the fundamental long-term research and to develop the discipline and systems technology required to maintain United States leadership in aeronautics and space.

TRACKING AND DATA ADVANCED SYSTEM: This program includes activities to perform studies and provide for the development of systems and techniques leading to improved tracking and data program capabilities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT
FY 1987 BUDGET ESTIMATES

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
SPACE STATION	155,500	230,000	205,000	410,000
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	391,400	459,300	437,000	465,500
SPACE SCIENCE AND APPLICATIONS	1,404,500	1,613,200	1,548,500	1,464,000
Physics and astronomy..................	677,200	630,400	607,100	539,400
Life sciences..........................	62,300	72,000	69,900	74,700
Planetary exploration..................	290,900	359,000	352,800	323,300
Solid earth observations...............	57,600	74,900	74,900	74,100
Environmental observations.............	212,700	317,500	289,800	367,900
Materials processing...................	27,000	34,000	35,000	43,900
Communications.........................	60,600	106,200	100,300	19,500
Information systems....................	16,200	19,200	18,700	21,200
COMMERCIAL PROGRAMS	9,500	41,100	28,100	45,300
Technology Utilization	9,500	11,100	11,100	13,300
Commercial Use of Space	(7,600)a/	30,000	17,000	32,000
AERONAUTICS AND SPACE TECHNOLOGY	492,400	522,000	522,000	601,200
Aeronautical research and technology....	342,400	354,000	354,000	376,000
Transatmospheric research and technology	---	---	---	45,000
Space research and technology...........	150,000	168,000	168,000	180,200
TRACKING AND DATA ADVANCED SYSTEMS	14,800	16,200	16,200	17,100
TOTAL	2,468,100	2,881,800	2,756,800	3,003,100

a/ In FY 1985, funded as part of the Office of Space Station ($.4 million), Office of Space Flight ($.5 million), Office of Space Science and Applications ($3.5 million), Office of Aeronautics and Space Technology ($1.2 million), and Office of Space Tracking and Data Systems ($2.0 million)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND DEVELOPMENT*

For necessary expenses, not otherwise provided for, including research, development, operations, services, minor construction, maintenance, repair, rehabilitation and modification of real and personal property; purchase, hire, maintenance, and operation of other than administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aeronautics and Space Administration; [$2,756,800,000] *$3,003,100,000*, to remain available until September 30, [1987] *1988*. *(Department of Housing and Urban Development-Independent Agencies Appropriations Act, 1986; additional authorizing legislation to be proposed.)*

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* See Part II for additional information

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Research and Development

Reimbursable Summary
(In thousands of dollars)

Research and Development	Budget Plan FY 1985	Budget Plan FY 1986	Budget Plan FY 1987
Space Transportation Capability	297,486	238,543	264,000
Space Science and Applications	326,125	345,627	345,000
Technology Utilization	3,475	2,274	3,000
Space Research and Technology	15,044	10,058	9,400
Aeronautical Research and Technology	56,882	54,224	55,500
Energy Technology	85,988	82,474	60,300
Total	785,000	733,200	737,200

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

SUMMARY OF BUDGET PLAN BY SUBFUNCTION
(In thousands of dollars)

Code		FY 1985	FY 1986	FY 1987
253	Space Flight....................................	546,900	642,000	875,500
254	Space Science, Applications and Technology........	1,564,000	1,744,600	1,712,000
255	Supporting Space Activities.......................	14,800	16,200	17,100
(250)	Subtotal, General Science, Space and Technology	2,125,700	2,402,800	2,604,600
402	Air Transportation...............................	342,400	354,000	398,500
	Total..	2,468,100	2,756,800	3,003,100

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1987 ESTIMATES
DISTRIBUTION OF RESEARCH AND DEVELOPMENT BUDGET PLAN BY INSTALLATION AND FISCAL YEAR
(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	National Space Technology Laboratories	Goddard Space Flight Center	Jet Propulsion Laboratory	Ames Research Center	Langley Research Center	Lewis Research Center	NASA Headquarters
Space Station	1985	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1986	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1987	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Space Transportation Capability Development	1985	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]
	1986	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]
	1987	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]
Space Science and Applications	1985	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1986	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1987	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Physics and Astronomy	1985	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
	1986	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
	1987	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
Life Sciences	1985	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
	1986	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
	1987	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
Planetary Exploration	1985	[illegible]	[illegible]	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
	1986	[illegible]	[illegible]	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
	1987	[illegible]	[illegible]	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
Solid Earth Observations	1985	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]
	1986	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]
	1987	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]
Environmental Observations	1985	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
	1986	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
	1987	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]
Materials Processing in Space	1985	[illegible]	[illegible]	—	[illegible]	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]
	1986	[illegible]	[illegible]	—	[illegible]	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]
	1987	[illegible]	[illegible]	—	[illegible]	—	—	[illegible]	—	[illegible]	[illegible]	[illegible]
Communications	1985	[illegible]	—	—	—	—	[illegible]	[illegible]	—	—	[illegible]	[illegible]
	1986	[illegible]	—	—	—	—	[illegible]	[illegible]	—	—	[illegible]	[illegible]
	1987	[illegible]	—	—	—	—	[illegible]	[illegible]	—	—	[illegible]	[illegible]
Information Systems	1985	[illegible]	—	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]
	1986	[illegible]	—	—	—	[illegible]	[illegible]	[illegible]	—	—	—	[illegible]
	1987	[illegible]	—	—	—	[illegible]	[illegible]	[illegible]	—	—	—	[illegible]
Commercial Programs	1985	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1986	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1987	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Technology Utilization	1985	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1986	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1987	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Commercial Use of Space	1985	—	—	—	—		—	—	—	—	—	—
	1986	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1987	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aeronautics and Space Technology	1985	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1986	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1987	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aeronautical Research and Technology	1985	[illegible]	[illegible]	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1986	[illegible]	[illegible]	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1987	[illegible]	[illegible]	—	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Space Research and Technology	1985	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1986	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1987	[illegible]	[illegible]	[illegible]	[illegible]	—	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Transatmospheric Research and Technology	1985	—	—	—	—	—	—	—	—	—	—	—
	1986	—	—	—	—	—	—	—	—	—	—	—
	1987	[illegible]	—	—	—	—	—	—	[illegible]	[illegible]	[illegible]	—
Tracking and Data Acquisition	1985	[illegible]	—	—	—	—	[illegible]	[illegible]	[illegible]	—	—	[illegible]
	1986	[illegible]	—	—	—	—	[illegible]	[illegible]	—	—	—	—
	1987	[illegible]	—	—	—	—	[illegible]	[illegible]	—	—	—	—
TOTAL BUDGET PLAN	1985	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1986	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1987	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE STATION **SPACE STATION PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

		1986		1987	
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate	Page Number
		(Thousands of Dollars)			
Definition............................	155,500	230,000	205,000	260,000	RD 1-4
Utilization..........................	(9,300)	(15,000)	(11,100)	(15,000)	RD 1-4
Advanced Development................	(50,100)	(82,000)	(70,800)	(83,000)	RD 1-4
Program Management/Integration......	(35,700)	(52,000)	(57,800)	(88,000)	RD 1-5
Operational Readiness...............	(2,900)	(7,000)	(5,300)	(17,000)	RD 1-5
System Definition	(57,500)	(74,000)	(60,000)	(57,000)	RD 1-5
Development...........................	---	---	---	150,000	RD 1-5
Total...............................	155,500	230,000	205,000	410,000	
Distribution of Program Amount by Installation:					
Johnson Space Center..................	63,566	111,900	100,202	146,800	
Kennedy Space Center..................	2,852	5,300	3,216	10,200	
Marshall Space Flight Center..........	36,009	45,400	37,242	37,000	
National Space Technology Laboratories	300	400	624	600	
Goddard Space Flight Center...........	16,379	17,800	16,611	15,000	
Jet Propulsion Laboratory.............	5,277	7,600	4,464	5,900	
Ames Research Center..................	3,240	4,500	1,943	1,700	
Langley Research Center...............	4,880	4,100	5,627	4,600	
Lewis Research Center.................	16,734	26,800	20,769	20,500	
Headquarters.........................	6,263	6,200	14,302	167,700*	
Total...............................	155,500	230,000	205,000	410,000	

*Development funds of $150,000 are shown at Headquarters pending decisions on the individual elements and related field center assignments.

OBJECTIVES AND STATUS

The Space Station will provide a unique capability to enhance the Nation's space science and applications program and to further the commercial utilization of space while stimulating advanced technologies. Development of the permanently manned Space Station, as directed by President Reagan, will follow a vigorous but deliberately-paced program plan which will permit us to maintain the preeminence in space our Nation has attained through various manned and unmanned programs.

The Space Station will be a multi-purpose, international facility providing a permanent human presence in space to conduct essential scientific and technical research, to support unique commercial activities and to perform operational tasks more efficiently in space. International participation in the Space Station program was encouraged by President Reagan in his 1984 State of the Union address. Canada, member states of the European Space Agency (ESA), and Japan have responded enthusiastically. Memoranda of Understandings (MOU) for the definition and preliminary design phase were executed with Canada, ESA, and Japan in the Spring of 1985 concurrent with the initiation of the NASA definition contracts. These international partners are undertaking parallel definition and preliminary design studies to identify Space Station elements that each of them may consider for development.

The Space Station will be designed to permit the system to evolve, as warranted, over time and to provide greater user utility and operational capabilities. Its manned and unmanned elements will be designed to facilitate on-orbit maintainability/restorability, operational autonomy, human productivity, and simplified user interfaces. Implicit in these objectives is the recognized need to optimize man/machine systems in space via automation, robotics and artificial intelligence technologies. During the definition period, NASA is conducting trade studies to evaluate various subsystems changes to the Space Station options. Changes to the reference configuration are being made to arrive at the optimum baseline configuration considering user requirements, systems efficiency, development and operations cost, and growth potential. Changes to the initial "power tower" reference configuration that have been baselined so far are: (1) dual keel; (2) "figure 8" module pattern; (3) 43.7 feet module length; (4) 14.7 psi cabin pressure; (5) assembly altitude of 220 nautical miles and a minimal operating altitute of 250 nautical miles; and, (6) 10 to the minus 5 g's microgravity level.

During the definition program, NASA is undertaking a Congressionally-mandated study to examine the feasibility of initially building and deploying a man-tended Space Station followed with a three to five year phase-in of a permanently manned capability. This study will be submitted to the Congress prior to the Administrator's selection of a baseline permanently manned Space Station configuration. All of the NASA centers and Space Station definition contractors are involved in this study which is progressing on schedule.

The Station and its platforms will be placed and maintained in low-Earth orbit by the Space Transportation System, thereby building upon the previous national investment in space. The initial launch of the Space Station elements will occur in the early to mid-1990's.

The definition and preliminary design phase will continue through FY 1987 and will provide the technical and programmatic plan for the Space Station program, including the completion of the detailed definition and preliminary design, the analysis and integration of national and international user community requirements, and the advanced development of technology options. A continuing emphasis on user requirements will be maintained throughout the definition phase as the preliminary engineering design evolves through subsystem advanced development and testing in dedicated test beds. Flight experiments on the Shuttle will be performed to prove system feasibility, and trade studies to optimize systems and operations will be conducted. This detailed system definition will provide assurance of achieving program objectives.

The development phase, beginning early in FY 1987, will include establishing system design requirements and performing detailed analysis for the initiation of the design and layout of the modules and subsystems, the design of ground support equipment and government furnished equipment, and the design and plans for tooling and manufacturing processes.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The FY 1986 budget estimate of $230 million was reduced in the Congressional review process by $25 million to $205 million. In addition, Congressional direction required that $5 million be added within the available funding for advanced technology work in support of delivery of a flight telerobotic system for a mobile remote manipulator and a smart front-end on the Orbital Maneuvering Vehicle to be used for remote operations and servicing.

To accommodate the effective $30 million budget decrease in the original budget plan, reductions and reallocations were made within the six definition phase functional areas.

Reductions in Utilization were taken in all five discipline areas. These reductions were achieved by eliminating parallel efforts between work package contractors and centers and by consolidating specific discipline definition efforts into common generic tasks that addressed the concerns of science and applications, commercial, and technology accommodations. The reductions in Advanced Development touched all technology areas. The effect of these reductions is the elimination of some technology options earlier than originally planned. For example, in the power technology area, all tasks relating to advanced solar arrays have been terminated including the flight experiment designed to study the interactions of space plasma with high voltage solar arrays. Similarly, in the propulsion/fluid management areas, the flight experiments to establish cryogenic fluid transfer (liquid helium) techniques have been eliminated. Examples of reduced tasks are a two-phase thermal control flight experiment and the data managment test bed engineering and operations tasks. The Program Management/Integration area was increased due to higher usage rates of facilities and equipment in various laboratories, such as the crew systems lab, the structures lab, and the antenna test range, as well as increased efforts in documentation and configuration management support. Reductions in Operational Readiness were achieved by reducing or eliminating parallel efforts between centers and by deferring some tasks into FY 1987. Parallel maintainability plan tasks were eliminated and facilities/ground systems tasks deferred into FY 1987. In the System Definition work, the reduction resulted in delays of portions of the definition and preliminary design contract deliverable products and studies into FY 1987.

BASIS OF FY 1987 ESTIMATE

This estimate provides for the initiation of development efforts as well as completion of the definition work, including the technology assessments, and the eight contracted studies begun in April 1985.

Utilization -- To ensure responsiveness to the national and international user community, customer advocacy groups established early in the program will continue to work with users to further define their requirements in the areas of science and applications, commercialization, and technology development. Other user requirements to be defined are: on-board accommodations; support for assembly, staging and servicing spacecraft; and maintainence or modification of equipment. The definition of consistent and user friendly interfaces is a key activity in FY 1987. Interface work will include the definition of access procedures for arranging for services, provisioning/replenishment requirements, and the methods for retrieval and protection of products, and/or data of both a scientific and technical nature. Definition of the user operational requirements will also be a focus of the Utilization program.

Advanced Development -- This activity provides for the continuing development of advanced technology options that are reliable and cost effective and will ensure that the initial Space Station configuration incorporates provisions for growth. Examples of key technologies on which work will continue in FY 1987 include: solar dynamic power generation and energy storage; regenerative life support system; food/hygiene technology; man/machine interfaces and work integration; two-phase thermal bus and two-phased fluid systems, material tests, and dynamic tests of representative structural elements. This effort is being conducted to validate the operation of selected technology options in the environment to which they will be exposed when incorporated in the Space Station.

Automation and robotics technology is applied throughout the advanced development effort. The limited crew size in the initial station dictates a development scenario that will result in maximum autonomy from the ground and a high level of automation and robotic activities. In FY 1986, Congress directed NASA to undertake an automation and robotic effort that will be continued in FY 1987.

Program Management/Integration -- This effort provides for the management and integration of all elements of the Space Station program including the input from international participants. The major components of this activity are the systems engineering and integration (SE&I) effort, the Technical and Management Information System (TMIS), and program support activities.

The SE&I effort includes the systems engineering and analysis of technical requirements and alternatives; the definition and integration of all elements that comprise the program; and the development of the master data base and the engineering master schedules. TMIS will be an integrated system of hardware, software, and procedures to collect, organize, and distribute engineering and management data among NASA centers, contractors and international partners. The program support activities provide management, technical, and institutional support from the individual centers necessary to sustain the development activities of the Space Station.

Operational Readiness -- The definition effort for operations includes the development of plans, requirements, and preliminary designs for the major operational support systems of integrated logistics management, space systems operations, launch/return operations, and user operations. International involvement and operational roles and missions will be assessed. The objective of all these activities is to insure the total operational readiness of the Space Station system, including platforms and ground support elements, in order to conduct a variety of scientific, technological and commercial missions.

System Definition -- Eight system definition contracts were initiated within four separate work packages in April 1985 for the initial definition and preliminary design of the Space Station and its evolution. Completion is scheduled for early FY 1987. In addition to permanently manned features, the contractors are also studying a man-tended approach which phases into a permanently manned capability. The contractors are also supporting the NASA SE&I activity by defining the configurations, interfaces, and functional requirements of individual system elements.

Development -- The development phase includes the contractor effort work packages, supporting development activities such as the NASA SE&I, the software support environment, and the evolvement of operational planning. Some of these supporting development activities will commence early in FY 1987. The SE&I effort will be performed primarily by civil service personnel at the Johnson Space Center with additional SE&I

support provided by other NASA centers. SE&I activities will include system requirements and analyses; interface design and control; and safety, reliability and quality assurance requirements. The engineering master schedule and other key systems level schedules will be expanded and maintained, systems level assembly and check-out logic will be refined, and systems level verification requirements and procedures will be established. The software support environment activity will provide the infrastructure for the development of common applications software required for flight and ground systems. Other supporting development activities to be performed by the Government with contractor support include the initiation of procurement of government-furnished equipment and the design of the ground support equipment. The ground support equipment will be required during the processing flow of the Space Station system for system level integration, test and check-out, as well as for processing and integration of payloads.

Work package contracts for the development phase are planned to begin incrementally, starting in mid-FY 1987. This contracted effort, as currently contemplated, will be divided into four major categories, which may be adjusted as a result of the definition studies and/or international participation. Present planning calls for one category to include the common modules, the environmental control and life support systems, the outfitting of laboratory and logistics modules, the auxiliary propulsion systems and related applications software. A second category will consist of the distributed systems (including communication and tracking, data management systems, thermal system, mechanisms and the connect/interconnect module); trusses and other structural items; the guidance, navigation and control system; the resources integration and Shuttle interface analysis; and, related applications software. The third category includes the platforms, the facilities and techniques for the servicing of free flyers and other space hardware, as well as the outfitting of laboratories and related applications software. [illegible]e final category consists of the power generation, power storage, and power management and distribution.

The design and development of the modules, structures, distributed subsystems and platforms will be phased to optimize fabrication, assembly and checkout flow times to support an initial launch of Space Station elements in the early to mid-1990's.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT — **SPACE TRANSPORTATION CAPABILITY DEVELOPMENT PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Spacelab..............................	55,700	96,700	92,900	89,700	RD 2-6
Upper stages..........................	137,400	122,000	122,000	85,100	RD 2-9
Engineering and technical base........	105,700	109,700	109,700	119,900	RD 2-12
Payload operations and support equipment..........................	56,300	63,900	63,900	72,600	RD 2-15
Advanced programs.....................	20,500	21,000	21,000	16,600	RD 2-17
Tethered satellite system.............	15,800	21,000	17,500	11,600	RD 2-19
Orbital maneuvering vehicle...........	---	25,000	10,000	70,000	RD 2-20
Total..............................	391,400	459,300	437,000	465,500	
Distribution of Program Amounts By Installation					
Johnson Space Center..................	118,000	115,100	119,600	121,400	
Kennedy Space Center..................	34,600	56,900	56,100	43,500	
Marshall Space Flight Center..........	92,700	128,400	113,100	185,600	
National Space Technology Laboratories	7,800	7,100	7,300	7,600	
Goddard Space Flight Center...........	1,000	---	1,000	1,600	
Jet Propulsion Laboratory.............	400	1,000	1,000	1,000	
Langley Research Center...............	800	200	400	500	
Lewis Research Center.................	124,100	115,300	75,500	30,000	
Headquarters..........................	12,000	35,300	63,000	74,100	
Total..............................	391,400	459,300	437,000	465,500	

PROGRAM OBJECTIVES AND JUSTIFICATION

The principle areas of activity in Space Transportation Capability Development are efforts related to the Spacelab, the Upper Stages that place satellites in high altitude orbits, the Engineering and Technical Base support at NASA centers, Payload Operations and Support Equipment, Advanced Programs study and evaluation efforts, the development and first flight of the United States/Italian Tethered Satellite System, and the development of the Orbital Maneuvering Vehicle.

Spacelab is a major element of the Space Transportation System (STS) that provides a versatile, reusable laboratory which is flown to and from Earth orbit in the orbiter cargo bay. The development program which has been carried out jointly by NASA and the European Space Agency (ESA) continues with the procurement of hardware for the Dedicated Discipline Laboratory, the Hitchhiker System, the Spacelab Pallet System, the Space Technology Experiment Platform and the intitial lay-in of spares. Operational missions for FY 1987 include a number of Spacelab module and Spacelab Pallet System missions.

Upper Stages are required to deploy payloads to orbits and trajectories not attainable by the Shuttle alone. The program provides for procurement of stages for NASA missions, for technical monitoring and management activities for government and commercial Upper Stages, a solid rocket motor integrity program to establish an engineering data base for solid stage components, and for the NASA share of the joint Air Force development effort being conducted with the Department of Defense (DOD) on the Centaur upper stage for use in the Shuttle.

The Engineering and Technical Base provides the core capability for the engineering, scientific and technical support required at the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL) for research and development activities.

Payload Operations and Support Equipment provides for developing and placing into operational status the ground and flight systems necessary to support the STS payloads during pre-launch processing, on-orbit mission operations and, when appropriate, post-landing processing. Included within this program area are the STS support services for NASA payloads, satellite servicing tools and techniques development, flight demonstrations and multi-mission payload support equipment.

The Advanced Programs effort identifies potential future space initiatives and provides technical as well as programmatic data for their definition and evaluation. Activity is focused on six major areas: advanced missions, satellite services, spacecraft systems, advanced transportation systems, crew systems, and generic space system capabilities. Advanced development activities are conducted to provide a basis for obtaining significant performance and reliability improvements and reducing future program risks and development costs through the effective use of new technology.

The Tethered Satellite System (TSS), a joint Italian/United States development effort, will provide a new capability for conducting space experiments in regions remote from the Shuttle orbiter. The objectives of the initial TSS mission planned for 1988 are twofold: (1) to verify the controlled deployment, operation, and retrieval of the TSS, and (2) to quantify the interaction between the satellite/tether and space plasma in the presence of a current drawn through the tether.

The development of the Orbital Maneuvering Vehicle, to be initiated in 1986, will provide a capability for payload delivery, retrieval, and servicing beyond that currently available in the STS.

OBJECTIVES AND STATUS

The first operational Spacelab flight (SL-3) and the second development flight (SL-2) were successfully flown during FY 1985. With the delivery of the instrument pointing system in the fourth quarter of FY 1985, the delivery of the major portion of the follow on procurement Spacelab hardware was completed. Additional hardware for the Dedicated Discipline Laboratory (DDL) flights, the Spacelab Pallet System (SPS), the Space Technology Experiment Platform (STEP),and the Hitchhiker system is being procured.

The major missions of the Spacelab system during FY 1986 will demonstrate its varied capabilities. The first reimbursable flight, Deutschland-1 (D-1), was flown during the first quarter of FY 1986. Astro-1, an astronomical observation of Halley's comet, and an Earth Observatory Mission (EOM-1/2), a mission flying several experiments previously flown on SL-1 will be flown during FY 1986. Also, the initial flights of the Goddard and Marshall Hitchhikers will be in FY 1986.

In Upper Stages, a joint development program with the DOD was initiated in FY 1983 for the use of the Centaur as an STS upper stage. The common vehicle, designated Centaur-G, accommodates a 40 foot long, approximately 10,000 pound payload in the orbiter payload bay, and is capable of placing it into geosynchronous orbit. A longer version of the Centaur-G, known as G Prime, is being developed by NASA for launch of the Galileo and Ulysses spacecraft in mid-1986. The G Prime is approximately 10 feet longer than the G Vehicle and is capable of placing a 14,560 pound payload into geosynchronous orbit from the orbiter. Two Centaur-G Prime vehicles are currently under procurement for the Galileo and

Ulysses missions. Procurement has been initiated for one Centaur-G vehicle to support the Magellan mission (formerly known as the Venus Radar Mapper mission) in 1988.

The commercially developed Payload Assist Modules (PAM) provide low cost transportation, principally for commercial spacecraft, from the Shuttle's low Earth orbit. The Delta class PAM-D is capable of injecting up to 2,750 pound payloads into geosynchronous transfer orbit. The PAM-DII will be capable of placing a 4,100 pound payload into geosynchronous transfer orbit and was used for the first time in launching an RCA payload for STS 61B in November 1985. The Atlas-Centaur class PAM-A is capable of inserting 4,400 pound payloads into the same orbit and was system-qualified in late 1984. Fourty PAM-D's have been successfully launched on the Delta, Atlas, and Space Shuttle. There have been 20 consecutive successful PAM-D missions as of January 1986.

The Inertial Upper Stage (IUS) was developed under a DOD contract to provide the capability to place payloads of up to 5,000 pounds into geosynchronous orbit. TDRS-2, which is the next NASA use of an IUS, is scheduled for launch in early 1986.

The Transfer Orbital Stage (TOS) is a three-axis stabilized perigee stage that is being commercially developed by the Orbital Sciences Corporation for use in the Shuttle. It will have the capability of placing 6,000 to 13,000 pounds into geosynchronous transfer orbit and thus bridges the gap between PAM-DII and Centaur. The scheduled launch availability is early 1987.

The Apogee Maneuvering Stage (AMS) is a three-axis stabilized liquid propellant apogee stage which is also being commercially developed by Orbital Sciences Corporation for use in the Shuttle. It will have the capability to place 5,200 pound payloads into geosynchronous transfer orbits when used alone or 6,500 pounds into geosynchronous orbit when combined with a TOS. Projected availability is late 1987.

In Payload Operations and Support Equipment, payload integration support and payload-related hardware are developed and furnished for NASA payloads. Multi-mission payload support equipment is developed and procurred including initial spares for cargo integration test equipment, fiber optic cabling and equipment for communication links between the payload procesing facilities and standard sets of wire harnesses for interconnection of mixed cargoes in the payload bay.

The Advanced Programs effort is focused on six major areas--advanced misions, satellite services, spacecraft system, advanced transportation systems, crew systems, and generic space system capabilities. Advanced planning and analysis efforts will increasingly be focused on long range manned mission options in and beyond Earth orbit. Satellite servicing systems will continue definition and advanced development work in remote and proximity operations. Continued efforts will be made in the areas of platform systems and servicing and advanced tether applications. Advanced transportation concepts will be studied, including orbit transfer vehicles (OTV's), propellant management, advanced launch vehicles, and advanced STS analytical tools. Systems supporting human presence in space as well as generic work in space structures, orbital debris management and retrieval, and artificial intelligence applications will be investigated.

The Tethered Satellite System (TSS) hardware development was initiated in FY 1984 following the completion of an advanced development phase initiated in FY 1983. Systems definition studies were completed in FY 1985. Comprehensive design and requirements validation; procurement of long lead time flight hardware elements and tooling; systems development and integration, and deployer manufacturing and integration will continue through FY 1987. The Italians started satellite and core equipment development in FY 1984, and a cooperative first flight is presently scheduled for 1988.

The Orbital Maneuvering Vehicle (OMV) completed early study and feasibility efforts in FY 1985 and is progressing toward contractor selection for full-scale hardware development by the middle of 1986. The OMV will be a reusable, remotely operated propulsive vehicle with the capabilty to deliver, retrieve and service payloads and spacecraft deployed at a wide range of altitudes and inclinations. Based on current planning, this capability will be available for use with the STS in 1991.

BASIS OF FY 1987 FUNDING REQUIREMENT

SPACELAB

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Development..........................	19,200	16,000	19,300	14,700
Operations...........................	36,500	80,700	73,600	75,000
Total................................	55,700	96,700	92,900	89,700

OBJECTIVES AND STATUS

The Spacelab is a versatile facility designed for installation in the cargo bay of the orbiter which affords scientists the opportunity to conduct scientific experiments in the unique environment of space. The reusable Spacelab system allows for the advancement of scientific research by serving as both an observatory and laboratory in space. Ten European nations, including nine members of the European Space Agency (ESA), have participated in this joint development program with NASA. ESA designed, developed, produced, and delivered the first Spacelab components; consisting of a pressurized module and unpressurized pallet segments, Igloo, command and data management subsystem, environmental control subsystem, power distribution systems, instrument pointing subsystem (IPS), and much of the ground support equipment and software for both flight and ground operations.

The remaining hardware is in Spacelab's development budget, including such major elements as the crew transfer tunnel, verification flight instrumentation, certain ground support equipment, and a training simulator. Support software and procedures development, testing, and training activities not provided by ESA, which are required to demonstrate the operational capability of Spacelab, are also included in NASA's funding. NASA has procured an additional Spacelab unit from ESA under terms of the ESA/NASA Memorandum of Understanding and the Intergovernment Agreement. With the delivery of the follow on procurement (FOP) IPS in the fourth quarter FY 1985, the delivery of the major portion of the FOP Spacelab unit was completed. Additional Spacelab hardware, primarily for Spacelab Dedicated Discipline Laboratory (DDL) flights and the initial lay-in of spare hardware, is being procured from Europe. The establishment of a depot maintenance program for United States-provided and European-supplied hardware will continue during FY 1986. NASA is developing two principal versions of the Spacelab Pallet System (SPS). One will support missions requiring the igloo and pallet in a mixed cargo configuration like the Astro series; the other version will support missions that do not require use of the igloo such as the Space Technology Experiment Platform (STEP) and the Tethered Satellite System. Development of the Hitchhiker system is also continuing.

Spacelab's operation budget includes mission planning, mission integration, and flight and ground operations. This includes integration of the flight hardware and software, mission independent crew training, system operations support, payload operations control support, logistical support and sustaining engineering.

The first Spacelab reimbursable flight, Deutschland-1 (D-1), was flown during the first quarter of FY 1986. Astro-1, an observation of Halley's comet, and an Earth Observatory Mission (EOM-1/2), a mission flying several experiments previously flown on SL-1, will also be flown during FY 1986. The initial flights of the Goddard Hitchhiker (HG-1) and the Marshall Hitchhiker (HM-1) will be in FY 1986. In addition to these missions, analytical and physical integration, configuration management and software development for future flights will be conducted. Procurement of spares for both NASA-developed hardware and for hardware developed by U.S. companies under contract with ESA will continue throughout FY 1986. Operation of the depot maintenance program for U.S.-provided and European-supplied hardware and the procurement of replenishment spares will continue in FY 1986.

CHANGES FROM 1986 BUDGET ESTIMATE

The $3.3 million increase in development is primarily due to the procurement of additional ground support equipment and flight spares, including instrument pointing system spares. In addition, there are modifications planned to existing hardware and a transfer of the dedicated cable harness from Payload Operations. The operations decrease of $7.1 million is due to changes in the manpower levels required to support the rephased Shuttle/Spacelab manifest.

BASIS OF FY 1987 ESTIMATE

Funding in FY 1987 is required for the continued procurement of initial lay-in of both United States and European source spares. The establishment of a depot maintenance system for U.S. and European-supplied hardware will also continue during FY 1987. Additionally, development of the STEP and procurement of hardware to support the DDL will continue.

Funding is also required for the FY 1987 Spacelab operational flights, including the International Microgravity Lab (IML-1), four Hitchhiker flights, Astro-2 and 3, Space and Life Sciences Laboratory SLS-1, Material Science Laboratory mission (3, 4, 5, 6 and 7), and other small payloads, all to be flown in FY 1987. FY 1987 funding is required to support flights to be flown in subsequent years, including the planned FY 1988 launch of an Earth Observation Mission (EOM-3), Sunlab-1/Dark Sky, SLS-2 and the Material Science Laboratory missions (8, 9, 10, and 11). Two additional reimbursable missions will be flown: the Japanese Spacelab mission (Spacelab-J) in FY 1988; and a West Germany mission (Spacelab-D2) in FY 1989. The support for these missions includes analytical integration, configuration management, hardware integration and software development and integration. Funding is also included to operate and maintain the MSFC and JSC Payload Operations Control Centers (POCC) required to support the Spacelab manifest. Spacelab operations also provides for replenishment spares, the operation of the depot for United States and European hardware and software, and sustaining engineering of all hardware and software.

BASIS OF FY 1987 FUNDING REQUIREMENT

UPPER STAGES

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Development...........................	38,000	5,700	3,900	4,900
Procurement and operations............	99,400	116,300	118,100	80,200
Total..............................	137,400	122,000	122,000	85,100

OBJECTIVES AND STATUS

The STS upper stages are required to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. The Inertial Upper Stage (IUS), the Centaur/STS, and the commercially developed Payload Assist Modules (PAM-A, PAM-D and PAM-DII) are currently available for use on the STS. Several other upper stages now being commercially developed, such as the Transfer Orbit Stage (TOS) and the Apogee Maneuvering Stage (AMS), will become available for use with the STS.

The IUS was developed under a DOD contract to provide the capability to place payloads of up to 5,000 pounds into geosynchronous orbit. The first IUS was successfully launched in October 1982 on a Titan 34-D booster. The first IUS/STS launch in April 1983 carried the TDRS-1 spacecraft. The IUS failed to operate nominally during the second stage boost. The IUS anomalies were resolved by joint USAF/NASA action, and the DOD/NASA/Industry Anomaly Investigating Team determined that the IUS was again ready for flight. The IUS operated nominally when deployed from STS-51C in January 1985. Four IUS vehicles have been procured by NASA for launch of the initial four Tracking and Data Relay Satellite System spacecraft; the first three were funded through the TDRSS contract while the fourth is funded under this budget element.

NASA and DOD have entered into a joint development program for a wide-body derivative of the Centaur stage as used in the Atlas-Centaur program. The common vehicle, designated Centaur-G, will accommodate a 40-foot long, approximately 10,000 pound payload in the orbiter payload bay, and be capable of placing it into geosynchronous orbit. It will be available in 1987. A longer and more powerful version of the Centaur-G, known as G Prime, is being developed by NASA for launch of the Galileo and Ulysses spacecrafts in mid-1986.

Two Centaur-G Prime vehicles are currently being procured for the Galileo and Ulysses missions. Procurement was initiated in FY 1985 for one G vehicle to support the Magellan (formerly Venus Radar Mapper) mission. The Air Force and NASA share common design and development costs for the Centaur-G up to a $150 million cap for DOD participation, as agreed to in the Memorandum of Agreement. The Air Force and NASA separately budget for hardware production and operations costs associated with each agency's missions. Both NASA and DOD plan additional procurement of vehicles at a later date to meet future requirements. The planned activities for Centaur in 1987 include the work required on the RL-10 engine to provide added capability for NASA and DOD missions.

The objective of the PAM program is to provide low cost transportation, principally of commercial spacecraft from the Shuttle's low Earth orbit to geosynchronous transfer orbit. The Delta class PAM-D is capable of injecting up to 2,750 pound payloads into geosynchronous transfer orbit. The Atlas-Centaur class (PAM-A) is capable of inserting 4,400 pound payloads into the same orbit. PAM's are being developed commercially, but NASA monitors the development and production to assure that the PAM is technically adequate and will be available when needed. Fourty PAM-D's have been successfully launched on the Delta, Atlas, and Shuttle as of January 1986. Twenty of these have occurred since the two PAM-D's failed on STS-11. The PAM-DII was developed commercially and is capable of injecting 4,100 pound payloads into geosynchronous transfer orbit. Its first mission, on STS-61B in November 1985, deployed an RCA satellite.

TOS is a three-axis stabilized perigee stage that is being developed commercially by the Orbital Sciences Corporation for use with the Shuttle. It will have the capability to place 6,000 to 13,000 pounds into geosynchronous transfer orbit, and thus bridge the gap between PAM-DII and Centaur. The scheduled launch availability is early 1987. A TOS-class vehicle is baselined for the Mars Observer mission in 1990. The Apogee Maneuvering Stage (AMS) is a three-axis stabilized liquid propellant apogee stage that is being developed commercially also by the Orbital Sciences Corporation for use with the Shuttle. It will have the capability to place a 5200 pound payload into geosynchronous transfer orbit when used alone or 6500 pounds into geosynchronous orbit when combined with TOS. Projected availability is late 1987.

The solid rocket motor integrity program was initiated during FY 1984, following the PAM failures on STS-11, to establish an urgently needed engineering data base for use of composite materials in upper stage motor nozzles, to minimize risk to planned missions and to restore user confidence in U.S. launch systems. Physical and mechanical properties of selected components are currently being examined and means of instrumenting manufacturing processes and their impact on material properties are being developed. Motor testing will be conducted to verify analyses and create an engineering data base.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The development decrease of $1.8 million is due to a restructuring of the RL-10 program. Production has increased $1.8 million reflecting Centaur cost increases of $4.3 million offset by minor PAM and IUS decreases.

BASIS OF FY 1987 ESTIMATE

The FY 1987 development funds are required to complete the RL-10 engine improvement program in order to provide increased capability for NASA and DOD missions. Also, technical monitoring of the TOS upper stage will be continued. Production and operations funds in FY 1987 are required to continue production of one Centaur-G vehicle to support the Magellan (formerly Venus Radar Mapper) mission scheduled for launch in 1988 and upper stages for the Mars Observer, TDRS-5 and TDRS-6. Vehicle selections are currently in the source evaluation process for upper stage vehicles for TDRS-5, TDRS-6, and the Mars Observer. Monitoring of the PAM-D, PAM-DII and TOS programs will continue. Funds are also required to support continuation of the solid rocket motor integrity program. Funding starts in FY 1987 on two upper stages, one PAM-D class and one AMS class, for the ESA and Japanese Solar Terrestial Physics spacecrafts.

BASIS OF FY 1986 FUNDING REQUIREMENT

ENGINEERING AND TECHNICAL BASE

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Research and test support.............	47,500	50,300	44,500	52,600
Data systems and flight support.......	16,200	17,000	19,000	14,100
Operations support....................	38,900	39,300	42,500	48,700
Launch systems support................	3,100	3,100	3,700	4,500
Total...............................	105,700	109,700	109,700	119,900

OBJECTIVES AND STATUS

The Engineering and Technical Base (ETB) provides the core capability required to sustain an engineering and development base for various NASA programs at the manned space flight centers. Additional center program support requirements above the core level are funded by the benefitting programs, such as Shuttle Operations and Shuttle Production and Capability Development. The centers involved are the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC), and the National Space Technology Laboratories (NSTL).

The core level of support varies from center to center due to programmatic and institutional differences. At JSC, the core level requirement is that one shift of operations be maintained in the engineering and development laboratories, the White Sands Test Facility, and reliability and quality assurance areas. The core level for the central computer complex is established as a two-shift operation. The funding for center operations base support is split between the ETB and Shuttle Operations budget elements in accordance with the principle that ETB will provide the core level and the benefitting program is responsible for funding additional support requirements. At KSC, due to its operational character, the core level provides for future studies and ground systems research and development. ETB funds at MSFC provide for multi-program support activities, including technical labs and facilities, computational and communications services, and at NSTL for facilities operations, including security.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The total funding for ETB has not changed in FY 1986. Reductions have been possible in research and test support by deferring equipment acquisitions and by reallocations between in-house laboratories. Data systems and flight support has increased to provide for additional communications and computational support. Operations support has increased to enhance base engineering and logistics activities support. Launch systems support includes additional development of beneficial applications of new technology to solve operational problems.

BASIS OF FY 1987 ESTIMATE

The requested funding for the ETB in FY 1987 provides for a continuation of the FY 1986 level of support for institutional research and development facilities and services at the centers. The increase in FY 1987 budget authority requirements over FY 1986 reflects increased rates at the contractor workforce.

In research and test support, effort will be continued on the provision for increased capabilities at MSFC for engineering and science projects enabled by acquisition of a Class VI computer system. This capability is required for the solution of more complex main engine three-dimensional dynamics modeling problems and for complex structural analyses. Present supporting activities at MSFC will be continued during FY 1986. At JSC, the requested funding will provide for a five-day, one-shift operation for the safety, reliability and quality assurance activities and for the engineering and development laboratories, such as the Electronic Systems Test Laboratory and the Thermal Test Area.

Data systems and flight support provide a minimal core level of support based on a five-day, two-shift operation of the central computer complex at JSC.

Operations support funding provides for the maintenance of technical facilities and equipment, chemical cleaning, engineering design, technical documentation and analysis, telecommunications, component fabrication, photographic support, and logistics support. Examples of specific services to be provided in FY 1987 include: (1) operation and maintenance of specialized electrical and cryogenic systems, and maintenance of test area cranes; (2) operation of shops to do metal refurbishing, anodizing, plating, stripping, and etching of selected items of in-house hardware; (3) engineering, installation, operation, and maintenance of closed circuit fixed and mobile television required for the support and surveillance of tests; (4) photographic services, including still and motion picture processing, and audio-visual mission support; (5) fabrication of models, breadboards, and selected items of flight hardware; (6) technical documentation services, telecommunications, and graphics; (7) technical services in support of center operations including receipt, storage, and issue of research and development supplies and equipment and transportation services; and (8) management services in support of center operations, including data management, microfilming, and preparation of technical documentation. In addition, FY 1987 funds will provide the basic level of institutional support at NSTL for continuing main engine testing activities.

In launch systems support, funds are required to continue work in the development of beneficial application of new technology to the solution of operational problems and development of improved operational capabilities for launch site hardware, ground processing and support systems.

BASIS OF FY 1987 FUNDING REQUIREMENT

PAYLOAD OPERATIONS AND SUPPORT EQUIPMENT

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Payload operations....................	41,600	53,400	54,600	66,900
Payload support equipment.............	14,700	10,500	9,300	5,700
Total..............................	56,300	63,900	63,900	72,600

OBJECTIVES AND STATUS

The Payload Operations and Support Equipment objectives are to centralize the provisioning of payload services, both unique and common, which are required beyond the basic standard services for NASA missions, and to provide multi-mission support equipment in support of payload operations. Payload operations provides unique hardware, analyses, and launch site support services to support STS missions. Payload support equipment funds the development and acquisition of multi-mission reusable ground support equipment required for a wide range of payloads. This includes test equipment required to checkout payload-to-orbiter interfaces at KSC, test equipment for checkout of NASA payloads at Vandenburg Air Force Base (VAFB), mixed cargo hardware such as standard cable harnesses, and displays and controls related to payload bay operations.

CHANGES FROM FY 1986 BUDGET ESTIMATE

Payload operations funding requirements increased by $1.2 million to support the development of a standard remateable umbilical for on-orbit spacecraft servicing. Payload support equipment estimates have decreased by $1.2 million reflecting a transfer of dedicated Spacelab wiring harnesses to the Spacelab program.

BASIS OF FY 1987 ESTIMATE

Payload operations funding is required to furnish continued payload services for currently scheduled NASA launches. Major NASA and joint endeavor payloads receiving support during this year include Spartans, Space Life Science Laboratory (SLS-2), Electrophoreses Operations in Space (EOS), Long Duration Exposure Facility Retrieval (LDEF), Spacelab Solar Telescope (Sunlab), Materials Science Laboratories (MSL), Astros, Shuttle Radar Laboratory (SRL), Tracking and Data Relay Satellite (TDRS), International Micogravity Laboratory (IML), Combined Release and Radiation Effects Satellit (CRRESS), Roentgen satellite (ROSAT), Shuttle Solar Backscater Ultra-Violet Instruments (SSBUV) and Large, High Capacity Heat Pipe Radiator (TEMP-3B). Sustaining engineering and operations support for the manned maneuvering unit will continue in support of NASA flight requirements. Further, efforts will continue to provide the means to maintain and repair satellites on-orbit by developing a series of tools, aids, and techniques, and to demonstrate capabilities and methods of improving the efficiency of on-orbit operations. These demonstrations will provide the experience necessary for realization of the Shuttle's potential for satellite servicing missions and on-orbit assembly functions.

FY 1987 funding for payload support equipment will be used for the development, test, and installation of mixed cargo hardware and test equipment, long lead procurement of equipment for NASA payloads at VAFB, procurement and installation of fiber optics, and continued procurement of cargo integration hardware required to meet the mission manifest.

BASIS OF FY 1987 FUNDING REQUIREMENT

ADVANCED PROGRAMS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Advanced programs.....................	20,500	21,000	21,000	16,600

OBJECTIVES AND STATUS

Advanced Program's principal objectives are to conduct mission requirements analyses, conceptual system definition, detailed system definition, and advanced and supporting developments to acquire the technical and programmatic data for the evaluation of new space flight initiatives. Future space program and systems requirements, configurations, costs, and capabilities are identified to provide the basis for development decisions on new space flight systems. Past program efforts have provided such information for new major Agency programs and systems including Apollo, Skylab, the STS and Space Station. Subsystem studies and advanced and supporting development efforts are conducted to demonstrate the required performance and reliability. Improvements to reduce future system program cost and schedule risks while increasing performance will also be investigated.

In FY 1986, the Advanced Programs effort is focused in six major areas--advanced missions, satellite services, spacecraft systems, advanced transportation systems, crew systems, and generic space system capabilities. Definition studies as well as advanced development efforts are being continued in the areas of satellite servicing systems; manned extravehicular activity; spacecraft and platform resupply, maintenance and repair; rendezvous and proximity operations; satellite maintenance and repair in low and geostationary Earth orbit; and autonomous capabilities. In spacecraft systems, definition activities continue for free flying and tethered space platforms in low and geostationary orbits operating from the Shuttle. Advanced transportation studies are focused on study of potential future reusable orbit transfer vehicles (OTV), space-based operations of OTV's, competitive aeroassist braking techniques for OTV, Shuttle-derived launch vehicle concepts, propellant scavenging, and aft cargo carrier concepts. Crew systems efforts will focus on definition and advanced development related to future space flight systems. Generic space system capabilities will include studies related to space debris. Preliminary definition and ground simulation evaluations of assembly and construction operations for large space systems and orbital structures will be pursued. NASA, in conjunction with the DOD, is investigating a heavy lift launch capability and associated advanced development.

The objective of efforts to be initiated in the advanced manned mission area will be the planning and analysis of potential follow-on programs to exploit the STS and the early Space Station. Integrated program options involving low Earth orbit, geostationary orbit, lunar and planetary missions will be investigated, with the multi-year purpose to develop goals, planning information, and infrastructure requirements for expanding manned presence in space beyond the period of the Space Station development and initiation.

BASIS OF FY 1987 ESTIMATE

In FY 1987, major emphasis will be placed on system concept definition and key advanced developments in crew systems, geostationary Earth orbital unmanned platforms, reusable OTV's, new capability mission kits for orbital maneuvering vehicles, future tethered systems applications, satellite servicing systems near and remote from the orbiter, and second generation shuttles. A major goal continues to be the conceptual definition of the systems architecture and space elements needed for space operations over the next twenty years.

The satellite servicing program element will continue to explore effective manned servicing concepts to extend STS operational capability for Earth orbit support of spacecraft, platforms, and constellation aggregates. The spacecraft systems program element will focus on geostationary platform capability, definition and delineation of critical mechanisms, and designs which require advanced development efforts. Detailed engineering systems analysis will be continued to determine the efficiency of future tethered platform applications. Completion of preliminary definition of orbit transfer vehicle systems will be accomplished in the advanced transportation element, including a detailed systems engineering understanding of space basing and what key advanced developments must be initiated. Second generation shuttle concept studies and advanced developments will also be conducted. In the crew systems area, new life support system concepts and advanced developments will be conducted focusing on post-Space Station era manned missions. Also, in the crew systems area, new capabilities for EVA will be pursued. Generic studies regarding orbital debris, large structures, and system applications will be continued. Advanced manned missions beyond the Space Station will continue to be studied with expanded scope and increased depth. Studies will be conducted to identify potential lunar/Mars missions and their potential demands on the STS.

BASIS OF FY 1987 FUNDING REQUIREMENT

TETHERED SATELLITE SYSTEM

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Tethered satellite system.............	15,800	21,000	17,500	11,600

OBJECTIVES AND STATUS

The development of a Tethered Satellite System (TSS) will provide a new facility for conducting space experiments at distances up to 100 kilometers from the Shuttle orbiter while being held in a fixed position relative to the orbiter. A number of significant scientific and engineering objectives can be uniquely undertaken with a TSS facility such as the observation of important atmospheric processes occurring within the lower thermosphere, new observations of crustal geomagnetic phenomena, and entirely new electrodynamic experiments interacting with the space plasma. This is being undertaken as a cooperative development program with the Italian government. Formal signing by representatives of both governments of a Memorandum of Understanding took place in March 1984.

The United States is responsible for overall program management, orbiter integration, and hardware development of the deployment mechanism which was initiated in FY 1984. The Italians initiated the satellite hardware development in 1984. They are responsible for the satellite development and instrument and experiment integration.

CHANGES IN FY 1986 BUDGET ESTIMATE

Funding requirements have decreased by $3.5 million to reflect a slower development schedule of the NASA deployer consistent with the pace of other elements of the program.

BASIS OF FY 1987 ESTIMATE

FY 1987 funding of $11.6 million will continue the hardware design and development leading to an engineering verification flight scheduled for 1988. The planning estimate for the total development cost for the United States activities remains at $60 million.

BASIS OF FY 1987 FUNDING REQUIREMENT

ORBITAL MANEUVERING VEHICLE

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Orbital maneuvering vehicle...........	---	25,000	10,000	70,000

OBJECTIVES AND STATUS

The Orbital Maneuvering Vehicle (OMV) will provide a new STS reusable extension capability for conducting orbital operations with spacecraft and payloads beyond the practical operational accessibility limits of the baseline STS. By means of direct man-in-the-loop control, the spacebasable reusable OMV, operating as far as 800-1400 nautical miles from the orbiter, will provide delivery, maneuvering, and retrieval of satellite payloads to and from altitudes or inclinations beyond the existing STS capability; reboost of satellite to original operational altitudes or higher; delivery of multiple payloads to different orbital altitudes and inclinations in a single flight; and safe deorbit of satellites which have completed their useful life. It will be designed to serve the Space Station as well and to accommodate the add-on of future "mission kits" as needed to support more advanced missions such as the servicing of satellites and platforms and the retrieval of space debris which could represent an orbital hazard to all future space missions.

CHANGES IN FY 1986 BUDGET ESTIMATE

The $15.0 million decrease for OMV reflects the implementation of Congressional actions on the FY 1986 budget request. This change will result in a delay of the first flight from 1990 to 1991.

BASIS FOR FY 1987 ESTIMATE

The funds provided in FY 1986 will be used to initiate OMV hardware development through competitively awarded contracts in the summer of 1986. FY 1987 funds will be used to continue this development effort leading to first flight in 1991.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1987 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR SPACE SCIENCE AND APPLICATIONS PROGRAMS

Programs	Budget Plan			
		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Physics and astronomy.................	677,200	630,400	607,100	539,400
Life sciences.........................	62,300	72,000	69,900	74,700
Planetary exploration.................	290,900	359,000	352,800	323,300
Solid earth observations..............	57,600	74,900	74,900	74,100
Environmental observations............	212,700	317,500	289,800	367,900
Materials processing in space.........	27,000	34,000	35,000	43,900
Communications........................	60,600	106,200	100,300	19,500
Information systems...................	16,200	19,200	18,700	21,200
Total.................................	1,404,500	1,613,200	1,548,500	1,464,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS — PHYSICS AND ASTRONOMY PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Hubble space telescope development....	195,000	127,800	127,800	27,900	RD 3-4
Gamma ray observatory development.....	117,200	87,300	87,300	51,500	RD 3-6
Shuttle/Spacelab payload development and mission management..............	105,400	135,500	108,300	115,100	RD 3-8
Explorer development..................	51,900	55,200	50,700	56,700	RD 3-11
Mission operation and data analysis...	109,100	119,900	118,000	172,700	RD 3-14
Research and analysis.................	39,900	42,300	51,500	51,100	RD 3-16
Suborbital program....................	58,700	62,400	63,500	64,400	RD 3-19
Total...............................	677,200	630,400	607,100	539,400	

Distribution of Program Amount by Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Johnson Space Center..................	7,328	9,500	9,874	15,190
Kennedy Space Center..................	4,997	7,250	6,854	4,786
Marshall Space Flight Center..........	338,824	283,298	293,217	246,466
Goddard Space Flight Center...........	193,087	216,996	169,054	140,721
Jet Propulsion Laboratory.............	60,913	34,525	47,413	53,110
Ames Research Center..................	22,505	27,500	29,920	29,666
Langley Research Center...............	2,914	3,233	1,625	1,250
Headquarters..........................	46,632	48,098	49,143	48,211
Total...............................	677,200	630,400	607,100	539,400

PROGRAM OBJECTIVES AND JUSTIFICATION

The major objective of the Physics and Astronomy program is to increase our knowledge of the origin, evolution, structure, and composition of the universe, including the Sun, the stars, and other celestial bodies. Space-based research is being conducted to investigate the structure and dynamics of the Sun and its long and short-term variations; cosmic ray, x-ray, ultraviolet, optical, infrared, and radio emissions from stars, interstellar gas and dust, pulsars, neutron stars, quasars, blackholes, and other celestial sources; and the laws governing the interactions and processes occurring in the universe. Many of the phenomena being investigated are not detectable from ground-based observatories because of the obscuring or distorting effects of the Earth's atmosphere.

To achieve the objectives of the Physics and Astronomy program, NASA employs theoretical and laboratory research; aircraft, balloon and sounding rocket flights; Shuttle/Spacelab flights; and free-flying spacecraft. Research teams involved in this program are located at universities, industrial laboratories, NASA field centers, and other government laboratories.

The scientific information obtained and the technology developed in this program are made available to the scientific communities for application to and the advancement of scientific knowledge, education and technology.

The Physics and Astronomy missions undertaken to date have been extraordinarily successful, and a number of missions continue to produce a rich harvest of scientific data; the International Ultraviolet Explorer (IUE) and the Solar Maximum Mission (SMM) are still operating. New scientific results are continually emerging from the analysis of the High Energy Astrophysics Observatories (HEAO) and Infrared Astronomical Satellite (IRAS) data sets.

Explorer satellites are relatively low cost but are extremely effective in missions which have been developed and launched since the beginning of our country's space program. Present examples are the Active Magnetospheric Paricle Tracer Explorer (AMPTE), launched in 1984, which is studying the solar wind at the subsolar point and identifying particle entry windows, energization processes and transport processes into the magnetosphere. The Infrared Astronomical Satellite (IRAS), developed in collaboration with the Netherlands and the United Kingdom, and launched in January 1983, made exciting discoveries and significant contributions to astronomical research as it observed the cool and obscured objects of the universe. While the spacecraft has completed operations, the analysis of the IRAS data will continue for several years.

Two major Explorer missions are now under development: the Cosmic Background Explorer (COBE) and the Extreme Ultraviolet Explorer (EUVE). In addition, a U.S. X-ray high resolution imager is being developed for launch in 1988 on the Roentgen Satellite (ROSAT), which is being developed by the Federal Republic of Germany. A Cosmic Ray Isotope Experiment is also being developed for flight in 1988 on a Department of Defense satellite.

The Hubble Space Telescope program will provide an international spaceborne astronomical observatory capable of measuring objects appreciably fainter and more distant than those accessible from the ground. This increased capability will allow us to address such basic questions as the origin, evolution, and disposition of stars, galaxies, and clusters, thus allowing us to significantly increase our understanding of the universe.

In 1988 the Gamma Ray Observatory mission will be launched by the Space Shuttle. This mission will measure gamma radiation and explore the fundamental physical processes powering it. Through the instruments flown on this mission unique information on astronomical objects such as quasars, black holes, and neutron stars may be examined.

The Shuttle/Spacelab program will continue, with flight of the ASTRO-1 mission and the first Earth Observation Mission (EOM) scheduled to occur in 1986. The ASTRO-1 mission will investigate the interstellar medium through x-ray observations, while the EOM will start a long-term series of studies related to the Earth's atmosphere and the solar constant. Activity will also be conducted on several future missions, including Astro-2, subsequent EOM's, Materials Science Labs, and the first dedicated Life Sciences mission. In addition, sounding-rocket-type instrumentation will be developed to be flown on the Space Transportation System to allow longer flight time of these relatively low-cost instruments.

Suborbital observations will continue to be conducted in FY 1987 from balloons, sounding rockets, Spartans, and high-flying aircraft that carry instruments above most of the atmosphere. An aircraft is being acquired and modified in FY 1986 and FY 1987 to replace the CV-990 research aircraft, "Galileo II", which was destroyed in an accident in July.

BASIS OF FY 1987 FUNDING REQUIREMENT

HUBBLE SPACE TELESCOPE DEVELOPMENT

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Spacecraft............................	174,100	113,900	113,900	24,900
Experiments..........................	20,900	13,900	13,900	3,000
Total.............................	195,000	127,800	127,800	27,900
Mission operations and data analysis.	(74,700)	(88,000)	(87,700)	(137,600)
Space transportation system operations	(28,000)	(41,500)	(40,100)	(---)

OBJECTIVES AND STATUS

The Hubble Space Telescope will make a major contribution to understanding the stars and galaxies, the nature and behavior of the gas and dust between them, and the broad question of the origin and scale of the universe. Operating in space above the atmospheric veil surrounding the Earth, the Hubble Space Telescope will increase, by more than a hundredfold, the volume of space accessible for observations. With its significant improvements in resolution and precision in light sensitivity and in wavelength coverage, the Hubble Space Telescope will permit scientists to conduct investigations that could never be carried out with ground-based observatories limited by the obscuring and distorting effects of the Earth's atmosphere.

The Hubble Space Telescope will enhance the ability of astronomers to study radiation in the visible and ultraviolet regions of the spectrum. It will be more sensitive than ground-based telescopes and will allow the objects under study to be recorded in greater detail. It will make observations possible of objects so remote that the light will have taken many billions of years to reach the Earth. As a result, we will be able to look far into the distant past of our universe. The Hubble Space Telescope will also contribute significantly to the study of the early state of stars and the formation of solar systems, as well as the observation of such highly-evolved objects as supernova remnants and white dwarf stars. With the Hubble Space Telescope, we may be able to determine the nature of quasars and the processes by which they emit such enormous amounts of energy; it may also be possible to determine whether some nearby stars have planetary systems.

The Hubble Space Telescope will be an automated observatory, delivered into orbit by the Space Shuttle. Data from its scientific instruments will be transmitted to Earth via the Tracking and Data Relay Satellite System. The Hubble Space Telescope design will permit in-orbit maintenance and repair, and/or retrieval by the Space Shuttle for return to Earth for required refurbishment and then relaunch by the Space Shuttle.

During FY 1985, significant progress was made towards completion of the Hubble Space Telescope (HST) development program. Almost all major elements of the spacecraft, including the Optical Telescope Assembly, the three flight Fine Guidance Sensors, the Science Instrument Control and Data Handling Unit, and the five Scientific Instruments have been delivered and assembled into the observatory at Lockheed. The Assembly and Verification (A&V) program of the integrated spacecraft began at Lockheed in FY 1985. HST functional, modal and electromagnetic compatibility testing have all been successfully completed. These tests verified the overall mechanical, electrical and structural integrated system design integrity and quality of workmanship. Especially gratifying were the pointing stability results from modal testing, which showed performance well within specifications.

In FY 1986, program focus will continue on the A&V activities at Lockheed. Major remaining A&V testing include acoustic, thermal vacuum and pre-ship functional. HST will then be shipped from Lockheed (California) to Kennedy Space Center for launch during the first quarter of FY 1987.

CHANGES FROM FY 1986 BUDGET ESTIMATE

While there are no changes in requirements from the FY 1986 budget, the launch date of the Hubble Space Telescope has been changed from August 1986 to October 1986. Resources have been added to FY 1987 to support the change in the launch date and for potential problems.

BASIS OF FY 1987 ESTIMATE

The FY 1987 funding is required for HST launch and orbital checkouts, related costs and associated contractor award fee payments.

BASIS OF FY 1987 FUNDING REQUIREMENT

GAMMA RAY OBSERVATORY DEVELOPMENT

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Spacecraft............................	91,400	59,700	59,700	35,500
Experiments and ground operations.....	25,800	27,600	27,600	16,000
Total.................................	117,200	87,300	87,300	51,500
Space transportation system operations	(5,400)	(12,000)	(14,800)	(22,600)

OBJECTIVES AND STATUS

The objective of the Gamma Ray Observatory mission is to measure gamma radiation from the universe, and to explore the fundamental physical processes powering it. Certain celestial phenomena are accessible only at gamma ray energies. The observational objectives of the Gamma Ray Observatory are to search for direct evidence of the synthesis of the chemical elements; to observe high energy astrophysical processes occurring in supernovae, neutron stars and black holes; to locate gamma ray burst sources; to measure the diffuse gamma ray radiation for cosmological evidence of its origin; and to search for unique gamma ray emitting objects.

Cosmic gamma rays represent one of the last frontiers of the electromagnetic spectrum to be explored. The low flux levels of gamma rays, and the high background they produce through their interaction with the Earth's atmosphere, coupled with the demand for better spectral, spatial, and temporal resolution of source features, combine to require that very large gamma ray instruments be flown in space for a prolonged period of time. Gamma rays provide unique information on the most intriguing astronomical objects yet discovered, including quasars, neutron stars, and black holes.

The Gamma Ray Observatory is scheduled for launch by the Space Shuttle in 1988. The spacecraft is designed to accommodate four scientific instruments and to allow for refueling by the Space Shuttle. Because of the necessity for long exposures, the spacecraft will be pointed in a fixed direction in space for periods of a few hours up to two weeks at a time.

In FY 1985, critical design review for the spacecraft system was completed. In addition, fabrication of instrument hardware continued. In FY 1986, assembly of the scientific instruments will be completed and the spacecraft fabrication and test will be underway.

BASIS OF FY 1987 ESTIMATE

The FY 1987 funding is required for science instrument integration and test with the spacecraft as well as system verification and test necessary for the planned 1988 launch.

BASIS OF FY 1987 FUNDING REQUIREMENT

SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Payload development & mission management	105,400	135,500	108,300	115,100
(Solar Optical Telescope Development)	(9,789)	(30,000)	(5,000)	(---)

OBJECTIVES AND STATUS

The objectives of Spacelab payload development and mission management are to develop instruments in order to conduct experiments and acquire new knowledge in the disciplines of physics and astronomy, to develop experiment interface hardware for materials processing, to develop sounding rocket class payloads for flight on the Space Shuttle, and to manage the mission planning, integration, and execution of all NASA Spacelab and attached payloads. This project also supports the development of all physics and astronomy experiments; system management and engineering development of flight equipment and software; payload specialist training and support; physical integration of the payloads with the Spacelab system; operation of the payloads in flight; dissemination of data to experimenters; and analysis of physics and astronomy flight data. In addition, this project funds the mission management efforts for all NASA Spacelab and other attached payloads.

Instruments are currently under development for several Shuttle/Spacelab missions with primary emphasis on physics and astronomy. These instruments are divided in two classes: multi-user instruments and principal investigator instruments. The multi-user instruments are those instruments that have a broad capability, can accommodate a number of principal investigator-furnished instruments, and have a larger user community. The principal investigator instruments are those proposed for a specific scientific investigation by a single investigator who may not have co-investigators.

Three ultraviolet telescopes are currently in development leading to a launch in March 1986 (ASTRO-1). This mission is designed to conduct investigations in ultraviolet imaging, spectrophotometry, and polarimetry at very high resolution. The ASTRO-1 mission will also carry two wide-field cameras, and will conduct unique scientific observations of Halley's Comet in the near-earth environment. ASTRO-1, as well as reflights of this instrumentation, is designed to allow scientific investigations of a broad range of objects, from nearby comets and planets to the most distant quasars.

Work is proceeding on instruments for the Shuttle High Energy Astrophysics Lab (SHEAL). The initial mission, SHEAL-1, which is planned for flight in early FY 1987, will study the celestial soft x-ray background and obtain information on the local interstellar medium. Instruments for a second mission, planned for early FY 1989, including a broad band x-ray telescope and an associated two-axis pointing system, are also under development.

Initial instrument development work is under way for Space Plasma Lab (SPL) missions planned for flight in the early 1990's. These missions are being developed to use the Earth's natural plasma environment as a laboratory to study in detail the behavior of plasmas as they are subjected to a variety of perturbances.

Mission management activities are continuing on several space science and applications missions. Examples include the Earth Observation Mission (EOM), the first of which is scheduled for launch in August 1986, and the Materials Science Laboratories, which comprise a series of material sciences experiments. Mission management activities also include integration, both analytical and physical, for other (non-OSSA) payloads. For example, the Space Station Heat Pipe Advanced Radiator Element heat pipe experiment payload is a test of a radiator system which has high potential for future spaceborne heat rejection systems.

Spacelab-2 and Spacelab-3 were flown successfully in April and July of 1985. Analysis of scientific data from these dedicated spacelab flights continues with significant results expected in FY 1986.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease in the FY 1986 estimated budget is consistent with Congressional direction and reflects a decision not to develop SOT at this time.

BASIS OF FY 1987 ESTIMATE

In FY 1987, mission management of the ongoing Spacelab missions will be continued. Mission management for the non-physics and astronomy missions includes all Spacelab efforts except instrument development and data analysis. These include the Space Life Sciences Lab and the International Microgravity Lab, both of which are scheduled for initial flight in 1987. Development of instruments for the Space Plasma Lab will continue, as will development of instruments for the Shuttle High Energy Astrophysics Lab and for the ASTRO series. FY 1987 funding is also required for the development and operations of low-cost sounding rocket class payloads which will be flown on the Space Shuttle to provide more flight opportunities for the science community.

BASIS OF FY 1987 FUNDING REQUIREMENT

EXPLORER DEVELOPMENT

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousand of Dollars)		
Cosmic background explorer............	30,570	25,400	24,900	16,700
Extreme ultraviolet explorer..........	13,426	24,100	15,900	32,400
Roentgen satellite experiments........	1,200	2,200	2,200	1,500
Combined release and radiation effects satellite..........................	1,500	---	3,300	2,200
Heavy nuclei collector................	2,900	3,300	1,700	1,300
Other explorers.......................	2,304	200	2,700	2,600
Total................................	51,900	55,200	50,700	56,700
Mission operations and data analysis	(19,761)	(19,700)	(18,700)	(23,100)
Transportation system operations	(4,600)	(17,700)	(17,800)	(30,900)

OBJECTIVES AND STATUS

The Explorer program provides the principal means of conducting investigations of stellar physics and of the near-Earth interplanetary environment that have limited specific objectives and that do not require major observatories. Included in the present program are studies of atmospheric and magnetospheric physics; the several magnetospheric boundaries; interplanetary phenomena; cosmic ray investigations; and x-ray, ultraviolet and infrared astronomy. Studies are conducted to define future high priority science explorer missions. NASA engages in cooperative missions with other federal agencies and other nations whenever such cooperation will assist in achieving the mission objectives.

Solar terrestrial and atmospheric explorers provide the means for conducting studies of the Earth's near-space environment. The program requires a wide variety of satellites in orbits extending from the very lowest reaches of the upper atmosphere to the interplanetary medium beyond the Earth's magnetosphere.

Astrophysics explorers have been instrumental in conducting the first astronomical sky surveys in the gamma ray, x-ray, ultraviolet, infrared, and low frequency radio regions of the electromagnetic spectrum.

In FY 1986, development will continue on the Cosmic Background Explorer (COBE), the Extreme Ultraviolet Explorer (EUVE), and on the x-ray imaging instrument to be flown on the German Roentgen Satellite (ROSAT). COBE will carry out a definitive, all-sky exploration of the infrared background radiation of the universe between the wavelengths of 1 micrometer and 9.6 millimeters. The detailed information which COBE will provide on the spectral and spatial distribution of low energy background radiation is expected to yield significant insight into the basic cosmological questions of the origin and evolution of the universe. Funding in FY 1986 will continue development and testing of the three COBE instruments and the spacecraft system. Mission design work will continue in FY 1986 on EUVE, which will carry out the first detailed all-sky survey of extreme ultraviolet radiation between 100 and 900 angstroms--a hitherto unexplored portion of the electromagnetic spectrum. In 1989 the EUVE mission will be launched using flight systems returned from the then completed Solar Maximum Mission (SMM). The EUVE/SMM spacecraft bus system will be available for in-orbit change-out of instruments, thus allowing the reuse of the original SMM spacecraft for missions like the X-Ray Timing Explorer, ROSAT a cooperative project between the Federal Republic of Germany and the United States, will perform high resolution imaging studies of the x-ray sky. The United States will provide the instrument and launch services, and Germany will provide the spacecraft and other instrumentation.

The Combined Release and Radiation Effects Satellite (CRRES) will be a NASA scientific experiment flown on an Air Force mission in 1988. The NASA CRRES experiment will be chemical releases in orbit to be observed from ground- and airborne-based instruments. The Heavy Nuclei Collector (HNC) will consist of an array of passive comic ray detectors to fly on the second Long-Duration Exposure Facility (LDEF). Scheduled for launch in 1986, the San Marco-D mission, a cooperative project with Italy, will include a group of U.S. experiments to study the relationship between solar activity and the Earth's meterological phenomena. FY 1986 funding will also support definition studies of potential future explorer missions, including the X-Ray Timing Explorer and the Far Ultraviolet Spectroscopy Explorer.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The total funding for explorers in FY 1986 was reduced by $4.5 million primarily to accommodate continued technology activities for the Gravity Probe-B. In addition reallocations were made between individual explorers to meet mission requirements and to restore Advanced Study funding.

BASIS OF FY 1987 ESTIMATE

The FY 1987 funding is required to continue COBE integration and test, to complete the United States' instrument activities on ROSAT, and to continue the CRRES and HNC developments. In addition development for the EUVE will continue, including preparation for the recovery of the SMM spacecraft and interface definition for the EUVE/SMM bus.

BASIS OF FY 1987 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
High energy astronomy observatory extended mission....................	5,632	4,500	4,700	3,500
Solar maximum mission extended mission............................	1,507	4,300	3,500	8,500
Solar maximum mission retrieval/repair mission............................	7,500	3,400	3,400	---
Hubble Space Telescope operations.....	54,100	57,300	57,300	68,500
Hubble Space Telescope maintenance and refurbishment.......................	20,600	30,700	30,400	69,100
Explorers............................	19,761	19,700	18,700	23,100
Total.............................	109,100	119,900	118,000	172,700

OBJECTIVES AND STATUS

The purpose of the mission operations and data analysis effort is to conduct operations and analyze data received from the physics and astronomy spacecraft after launch. The program also supports the continued operation of a number of spacecraft after their originally planned objectives have been achieved, for purposes of conducting specific investigations that have continuing, high scientific significance. The funding supports the data analysis activities of the many investigators at universities and other research organizations associated with astrophysics and solar terrestrial operational satellite projects. Actual satellite operations, including operation control centers and related data reduction and engineering support activities, are typically carried out under a variety of mission support or center support contracts.

In addition to the normal support required for mission operations, the Hubble Space Telescope program encompasses several unique aspects which must be provided for in advance of the launch. The

Hubble Space Telescope is designed to operate for more than a decade, using the Space Shuttle/Orbital Maneuvering Vehicle combination and/or Space Station for on-orbit maintenance of the spacecraft and in-orbit changeout or repair of the scientific instruments.

The Hubble Space Telescope will be used primarily by observers selected on the basis of proposals submitted in response to periodic solicitations. Science operations will be carried out through an independent Hubble Space Telescope Science Institute. The Institute will operate under a long-term contract with NASA. While NASA will retain operational responsibility for the observatory, the Institute will implement NASA policies in the area of planning, management, and scheduling of the scientific operations of the Hubble Space Telescope.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The total funding in FY 1986 was decreased by $1.9 million primarily to accommodate continued technology activities for the Gravity Probe-B. In addition a reallocation was made to meet HEAO data analysis requirements.

BASIS OF FY 1987 ESTIMATE

During FY 1987, the first year of Hubble Space Telescope (HST) operational use, HST mission operations and data analysis funding will primarily provide for scientific research and preparation for the first planned maintenance mission. Research funds will be granted to approximately 125 research teams selected for this initial period. Research and publication of results will be done at both the Space Telescope Science Institute and at researcher's home institutions. Funds also provide for an operations mission contractor, ground system maintenance and enhancement, design and development of second generation scientific instruments and development of orbital replacement units required during servicing. FY 1987 funds will provide support for the continued mission operations and data analysis activities for the International Ultraviolet Explorer and the Solar Maximum Mission, continued analysis of the extensive data obtained by the Infrared Astronomical Satellite and the High Energy Astronomy Observatories (HEAO). The FY 1987 funding will provide for the continued support of the data analysis and Guest Investigator programs on the HEAO-2 and -3 Missions.

BASIS OF FY 1986 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology....	22,300	27,900	30,700	30,300
(Gravity Probe-B Definition).........	(3,900)	(800)	(9,000)	(9,000)
Advanced technology development.......	12,100	8,500	15,100	14,600
Data analysis.........................	5,500	5,900	5,700	6,200
Total................................	39,900	42,300	51,500	51,100

OBJECTIVES AND STATUS

This program provides for the research and technology base necessary to define, plan and support flight projects. Preliminary studies to define missions and/or payload requirements are carried out, as are theoretical and ground-based supporting research and advanced technology development (ATD). Activities included are supporting research and technology (SR&T), ATD, and data analysis.

o Supporting Research and Technology (SR&T): The objectives of supporting research and technology are to: (1) optimize the return expected from future missions by problem definition, development of advanced instrumentation and concepts, and sound definition of proposed new missions; (2) enhance the value of current space missions by carrying out complementary and supplementary ground-based observations and laboratory experiments; (3) develop theories to explain observed phenomena and predict new ones; and (4) strengthen the technological base for sensor and instrumentation development and conduct the basic research necessary to support our understanding of astrophysics and solar-terrestrial relationships.

Research is supported in the disciplines of astronomy, astrophysics, gravitational physics, and solar and heliospheric physics. Research in astronomy and astrophysics involves the study of stars, galaxies, interstellar and intergalactic matter, and cosmic rays. The work in solar and heliospheric physics involves the study of the solar atmosphere and the influence of the Sun on interplanetary phenomena. The theory activities are related to all the Physics and Astronomy disciplines and are critical to the correlation of available information. The SR&T funding will provide for continuation of definition work on Gravity Probe-B. The development of new instruments, laboratory and theoretical studies of basic physical processes, and observations by ground-based and balloon-borne instruments will also be continued. Results achieved in the SR&T program will have a direct bearing on future flight programs. For example, the development of advanced X-ray, ultraviolet, and infrared astronomy imaging devices under this program will probably enable spacecraft to carry instruments for astronomical observations which have increases of orders of magnitude in sensitivity and improved resolution over currently available detectors.

The SR&T program carries out its objectives through universities, non-profit and industrial research institutions, NASA centers and other government agencies. Current emphasis is being placed on studies of advanced instrumentation with increased sensitivity and resolution.

o Advanced Technological Development (ATD): The advanced technological development activities support detailed planning and definition of new potential physics and astronomy missions. ATD activities assure that future missions address the scientific questions most important to the evolution of knowledge in the field, and that those missions use the appropriate technology and techniques. Funding is applied to the definition and preliminary design for specific missions or subsystems/elements critical to eventual mission development in order that technical readiness and resources may be adequately defined before the missions are proposed for implementation.

Candidate missions for the 1980's and early 1990's that require ATD activities include the Advanced X-Ray Astrophysics Facility (AXAF) and the Space Infrared Telesope Facility (SIRTF). The AXAF mission, which is the first priority new mission recommendation in astronomy by the National Academy of Sciences, will study stellar structure and evolution, active galaxies, clusters of galaxies and cosmology. The AXAF's imaging X-ray telescope is planned to have a sensitivity approximately 100 times that of HEAO-2 and a resolution increase of nearly a factor of twenty. The SIRTF will observe faint, cool infrared sources in the universe and significantly build on the IRAS science foundation. Major Spacelab payloads being considered for future missions and requiring advanced technological development support include the Pinhole/Occulter Facility, a detector for imaging hard X-rays. During FY 1986, major emphasis will be on the AXAF competitive Phase B definition as well as continued technological preparation for SIRTF.

o Data Analysis: The acquisition, analysis and evaluation of data represents the primary purpose of the laboratory, balloon, rocket and spacecraft activities. While a considerable amount of analysis is done during the prime project phase, experience has shown that considerably more time is required to reap the full benefit from these programs. This will come about only when the data is correlated with other projects, when detailed cause-and-effect studies are made with data sets from other sources, when very long-term (e.g., one solar cycle) effects can be studied by using complementary sets of data, and when new ideas that originate from the results of the initial analysis can be tested. For example, astronomical image processing facilities have been developed to take advantage of high technology developed under the Landsat and planetary programs. This technology allows astronomers to extract a maximum amount of information from the data they obtain from standard photographic emulsions and more advanced imaging techniques such as the charge-coupled devices now being ground tested for use on the Hubble Space Telescope.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The total funding in FY 1986 was increased by $9.2 million primarily to accommodate the continued technology activities for Gravity Probe-B. In addition reallocations were made to reflect the Advanced X-Ray Astrophysics Facility and Space Infrared Telescope Facility efforts in FY 1986.

BASIS OF FY 1987 ESTIMATE

During FY 1987, the supporting research and technology program will support those tasks which contribute to maintaining a firm base for a viable physics and astronomy program. FY 1987 funding will also support continued studies on future potential candidate missions such as the Advanced X-ray Astrophysics Facility and the Space Infrared Telescope Facility. In the data analysis activities to be carried out at university and government research centers in FY 1987, emphasis will be placed on correlative studies involving data acquired from several sources (spacecraft, balloons, sounding rockets, research aircraft and ground observatories). The Gravity Probe-B activities in FY 1987 are designed to verify the entire GP-B design, leading to confidence in the information necessary to decide if we should enter into the next phase of design and development activities.

BASIS OF FY 1987 FUNDING REQUIREMENT

SUBORBITAL PROGRAMS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Sounding rockets......................	25,680	25,700	25,400	26,500
Airborne science and applications.....	22,000	23,400	26,300	24,100
Balloon program.......................	6,767	7,600	6,100	7,900
Spartan...............................	4,253	5,700	5,700	5,900
Total...............................	58,700	62,400	63,500	64,400

OBJECTIVES AND STATUS

The suborbital program uses balloons, aircraft, and sounding rockets to conduct versatile, relatively low cost research of the Earth's ionosphere and magnetosphere, space plasma physics, stellar astronomy, solar astronomy, and high energy astrophysics. Activities are conducted on both a domestic and an international cooperative basis.

o Sounding Rockets:

A major objective of the sounding rocket program is to support a coordinated research effort. Sounding rockets are uniquely suited for performing low altitude measurements (between balloon and spacecraft altitude) and for measuring vertical variations of many atmospheric parameters. Special areas of study supported by the sounding rocket program include the nature, characteristics, and composition of the magnetosphere and near space; the effects of incoming energetic particles and solar radiation on the magnetosphere, including the production of aurorae and the coupling of energy into the atmosphere; and the nature, characteristics, and spectra of radiation of the Sun, stars and other celestial objects.

Additionally, the sounding rocket program provides the physics and astronomy program with the means for flight testing instruments and experiments being developed for later flight on the Shuttle/Spacelab and space probes and for calibrating and obtaining vertical profiles in concert with current orbiting spacecraft.

Of significant interest was a campaign in Greenland in FY 1985 to be followed by an additional campaign in FY 1987. Two launches will be conducted in FY 1986 to observe Halleys Comet.

- Airborne Science and Applications:

Research with instrumented jet aircraft has been an integral part of the overall NASA program in physics and astronomy since 1965. For astronomy research, the airborne science and applications program utilizes a C-141 instrumented with a 91-centimeter infrared telescope. The C-141 "Kuiper Airborne Observatory", which began operational flights in 1974, is a full-scale, manned facility. This aircraft provides a large payload capacity and facilities for extending observations over any region of the Earth, and can operate at high altitudes (nearly 13 kilometers), in order to provide a cloud-free site for astronomical observations and auroral geophysics experiments. The possibility of conducting observations at this altitude, above most of the infrared-absorbing water vapor of the Earth's atmosphere, has been essential in expanding astronomical observations in the infrared region of the electromagnetic spectrum from one micrometer to hundreds of micrometers.

In FY 1985 approximately 70 science flights were flown with the C-141 to make far-infrared observations, including exploration of the star-forming regions and of other areas in our own galaxy. A strong infrared source was detected near the galactic center, suggesting the presence of a black hole. In FY 1986, nearly 80 flights are planned, including an expedition to Australia in the spring in order to make detailed observations of Comet Halley near perihelion and to study other sources only visible in the southern hemisphere. C-141 observations in December 1986 have already discovered the presence of water vapor in Comet Halley.

This program also provides flight support to other major segments of the Space Science and Applications program, with an aircraft fleet currently consisting of two U-2C's, one ER-2, one Learjet, and one C-130. In addition, a replacement aircraft is being acquired to replace the CV-990 research facility, "Galileo II", which was destroyed in a fire in 1985. These aircraft serve as test beds for newly-developed instrumentation and permit the demonstration of new sensor concepts prior to their flight on satellites and the Spacelab. The data acquired during these flights are used to refine algorithms and to develop ground data handling techniques. An example of such activities is flights in the ER-2/U-2C's to acquire simulated thematic mapper data. Another principal use of ER-2/U-2C's is to acquire stratospheric air samples and conduct in situ measurements at altitude ranges above the capability of more conventional aircraft and below those of orbiting satellites. This capability is important in the study of stratospheric transport mechanisms.

- Balloon Program:

For the development of scientific experiments for space flight and for independent scientific missions, it is desirable to test the instrumentation in the space radiation environment and to make observations at altitudes which are above most of the water vapor in the atmosphere, particularly for observations in infrared, gamma ray, and cosmic ray astronomy. In many instances it is necessary, because of size and weight, as well as low cost, to fly these experiments on balloons.

In addition to the level of effort observing program, significant emphasis has and will be placed on R&D efforts to increase reliability in flight missions requiring a heavy lift capability (i.e. greater than 3500 lbs).

The balloon program funding is required for purchase of balloons, helium, launch services, tracking and recovery, and maintenance and operations of the National Science Balloon Facility (NSBF) at Palestine, Texas. This facility supports the launch of over 75 to 80 percent of NASA's balloon payloads, and it is the nation's primary means for carrying out large scientific balloon operations. Funding for the experiments which are flown on balloons is provided from supporting research and technology programs.

- Spartan Program:

The Spartans are low-cost Shuttle payloads flown as autonomous subsatellites to be deployed and retrieved by the Space Shuttle. Six Spartan missions are currently under development, each with a different scientific instrument. Spartans allow the accomplishment of single, specific scientific objectives with efficiency and simplicity. The first Spartan flew successfully in 1985. It obtained valuable new x-ray data on the nuclear region of our own galaxy and on the vast cluster of galaxies in the constellation Perseus. Detailed analysis of this data is currently underway. The Spartan program will continue to mature with a major milestone in 1986 being the launch of Spartan Halley, which will record ultraviolet light emitted by the comet's chemistry when it is closest to the sun and most active. A third Spartan mission, to be flown in FY 1987, will consist of a 17-inch diameter Solar Telescope and include an ultraviolet coronagraph and a white light coronagraph to measure the intensity and scattering properties of solar light.

CHANGES FROM FY 1986 BUDGET ESTIMATES

The total funding in FY 1986 was increased by $1.1 million. This increase is a net of actions to provide 6.9 million within the suborbital program, primarily to accommodate modifications to the replacement aircraft for the CV-990 which was destroyed in an accident.

BASIS OF FY 1987 ESTIMATE

FY 1987 funds will provide for continuation of the sounding rocket program, for continuation of the development of a full complement of Spartans and for the continuation of the balloon program as well as management and operation of the NSBF. This funding is also required to continue definition activities on potential future long-duration balloon flights. In FY 1987, the Airborne Science and Applications funding will be used to continue operation of the Kuiper Airborne Observatory, to fly the U-2C's, ER-2, and Learjet to continue infrared astronomy exploration, acquire stratospheric air samples, test newly developed instrumentation, permit the demonstration of new sensor concepts, etc.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS

LIFE SCIENCES PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Life sciences flight experiments......	27,100	33,400	34,000	36,700	RD 4-5
Research and analysis................	35,200	38,600	35,900	38,000	RD 4-7
Total..............................	62,300	72,000	69,900	74,700	
Distribution of Program Amount By Installation					
Johnson Space Center..................	22,329	26,550	22,058	26,860	
Kennedy Space Center..................	2,524	2,100	2,655	2,695	
Goddard Space Flight Center...........	310	200	383	410	
Jet Propulsion Laboratory.............	316	1,500	1,397	1,575	
Ames Research Center..................	25,709	28,850	27,859	30,345	
National Space Technology Laboratories	50	100	47	55	
Langley Research Center...............	523	600	495	510	
Headquarters..........................	10,539	12,100	15,006	12,250	
Total..............................	62,300	72,000	69,900	74,700	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS **LIFE SCIENCES PROGRAM**

PROGRAM OBJECTIVE AND JUSTIFICATION

The goals of the Life Sciences program are to provide a sound scientific, medical, and technical basis for safe and effective manned space flight, and to advance the understanding of the basic mechanisms of biological processes by using the unique capabilities of the space program. Results from the research program are applied to: the immediate needs in the maintenance and health of the astronauts; understanding biological mechanisms and the response of biological systems to weightlessness; the design of the advanced life support systems for use on future missions; and understanding the biosphere of the planet Earth, as well as the origin, evolution, and distribution of life in the universe.

The Life Sciences program is the key to developing a capability to sustain a permanent manned presence in space and to utilize the space environment to study living systems. These activities include both ground-based and space research efforts which are mutually supportive and integrated, and use a composite of disciplines and techniques in both biology and medicine to address space-related medical problems and fundamental biological processes.

The Life Sciences research and analysis program includes five major elements: 1) space medicine, which is focused on the health and well-being of space crews by understanding and preventing any adverse physiological changes which occur in space flight and upon return to earth; 2) advanced life support systems, which is a program of research and technology development for life support systems necessary to maintain life in space autonomously for long periods of time; 3) gravitational biology, which consists of flight and ground-based experiments that focus on using microgravity as a biological research tool to understand basic mechanisms of the effects of microgravity on plants and animals; 4) exobiology research, which is directed toward understanding the origin and distribution of life and life-related molecules on Earth and throughout the universe; and 5) biospheric research, which is directed toward understanding the interaction between life on Earth and its physical and chemical environment.

The goals of the Space Medicine program are to assure space crew members' health and ability to function effectively in the space environment. In the future, experience gained from medical operations in space flight will allow a broader segment of the population to participate in all aspects of space missions. Particular emphasis is being placed on testing countermeasures designed to prevent physiological problems associated with exposure to the space environment. It is essential that long-term monitoring of space flight crews be performed in a standardized and organized fashion in order to develop risk factors and establish the long-term clinical significance associated with repeated exposure to the space environment. In addition, biomedical research is designed to understand the physiological basis for problems encountered in manned space flight. Areas of emphasis include: vestibular dysfunction, cardiovascular deconditioning, immunology, bone and muscle loss, and radiation damage. This research concentrates on trying to define potential flight protocols and countermeasures, first as space flight experiments and ultimately on an operational basis.

The Advanced Life Support System program seeks ways to develop technologies for more efficient life support systems for the space program. It also undertakes the scientific work in chemistry and biology necessary to understand how life can be maintained in closed systems which receive only energy from the external environment. All are aimed at potential future needs of long duration manned space flight and lunar colonization.

The goals of the Gravitational Biology program are to further our understanding of basic physiological mechanisms and the effects of microgravity on plants and animals through the use of the space environment. Research, which includes both ground-based and space flight experiments, is focused on clarifying gravity-sensing systems; the effects of microgravity on reproduction, development, physiology, and behavior; and gravity's influence on the evolution of life on Earth. These studies are aimed at providing information essential to the long-term survival of plants and animals in space as well as an understanding of gravity's past and present effect on life.

The Exobiology efforts are concentrated on studies of life's origin, with particular emphasis on developing sound hypotheses which could lead to discovering the relationships which may link the formation of the solar system and the origin of life. Ground-based research on model systems and analysis of extraterrestrial materials, coupled with the results of planetary flight experiments, are clarifying the mechanisms and environments responsbile for the chemical evolution leading to life's origin. Studies of life's origin and evolution will be extended to enhance our understanding of the interaction of the biota with the Earth's present environment, and thereby provide a more comprehensive picture of life--its past, present, and future.

The Biospherics Research Program seeks to utilize NASA technology in remote sensing, combined with ground-based research and mathematical modeling, to study the biosphere, (the thin layer around the Planet that contains all of terrestrial life). The goal of the program is to understand the structure and function of the biosphere in order to understand how global biological processes and planetary properties modify and modulate one another. Knowledge of these interactions will ultimately allow predictions of how the habitability of the Earth can be affected by human activities or natural phenomena.

BASIS OF FY 1987 FUNDING REQUIREMENT

LIFE SCIENCES FLIGHT EXPERIMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Life sciences flight experiments......	27,100	33,400	34,000	36,700

OBJECTIVES AND STATUS

The objective of the Life Sciences Flight Experiments program is to assimilate information and scientific questions from the various life sciences disciplines and translate them into payloads designed to expand our understanding of the basic physiological mechanisms involved in adaptation to weightlessness. The program includes selection, definition, inflight execution, data analysis, and reporting on medical and biological investigations involving humans, animals and plants. Past experience indicates that humans clearly undergo physiological changes in weightlessness. Thus far these changes appear to be reversible upon return to Earth; however, many of the observed changes are physiologically significant and are not well understood. With weightless exposure beyond several months, these changes may prove irreversible. Shuttle/Spacelab missions are suitable for gaining a greater understanding of the early response to weightlessness, which will improve the management of several existing problems (e.g., space adaptation syndrome) and will enhance the confidence of estimating the physiological consequences of more sustained weightless exposure (e.g. Space Station).

Current activities include the development of life sciences flight experiments to be flown on the first dedicated Life Sciences mission (Space Life Sciences -1 (SLS-1)) which is scheduled for early 1987 and will concentrate on human investigations. Many of the experiments and associated flight hardware flown on earlier Shuttle flights have supported and enhanced the preparations for SLS-1 and subsequent missions. In addition, experiment development activities are currently underway to support the flight of the first International Microgravity Laboratory-1 (IML-1) mission in mid 1987. Human vestibular experiments, plant investigations, and animal support hardware test and checkout are planned.

The investigations planned for SLS-1 and IML-1 explore the known problems of manned space flight through the use of both human and animal subjects, and also include key investigations in gravitational biology. Principal investigators will examine cardiovascular adaptation, space adaptation syndrome, muscle atrophy, bone demineralization, early anemia in weightlessness, and the effects of weightlessness on plant and animal development. The SLS-1 mission will be unique in several respects: it will be the first Shuttle/Spacelab mission dedicated entirely to life sciences, and will involve highly skilled scientists as payload specialists, thus permitting the use of numerous experimental techniques and procedures never before utilized in space.

In addition to the preparation and flight of previously selected experiments, increasing activity and emphasis will be directed towards the study and definition of experiments which can be conducted on the Space Station.

CHANGES FROM THE FY 1986 BUDGET ESTIMATE

Increased funding is required in FY 1986 to provide $2.5 million for modifications to the Research Animal Holding Facility which is used on Shuttle Flights. This increase has been partially offset through changes associated with other flight projects.

BASIS OF FY 1987 ESTIMATE

FY 1987 funding is required for the final preparation and flight of approved experiments and the continued definition and development of new experiments and hardware that will be flown on future Spacelab/Shuttle missions - i.e., Shuttle middecks, Japanese J mission, the second dedicated life sciences mission (SLS-2), German D-2 mission, IML-2, and SLS-3. The selection of new experiments through the Announcement of Opportunity (AO) process is continuing. In addition, increasing activities are planned to support the development of Space Station Life Sciences experiments and complement.

BASIS OF FY 1987 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Life sciences research and analysis...	35,200	38,600	35,900	38,000

OBJECTIVES AND STATUS

The research and analysis activity of the Life Sciences program is concerned with ground-based and pre-flight research in basic biology and in those medical problem areas that affect manned spaceflight. The program is comprised of five elements: (1) space medicine (2) advanced life support systems research; (3) gravitational biology; (4) exobiology; and (5) biospheric research.

The Life Sciences Space Medicine program is responsible for bringing the technology and practice of medicine to bear on solving the problems of sustaining, supporting, and protecting individuals working in the space environment. The program provides the means for assuring the physical welfare, performance, and adequate treatment of in-flight illnesses or injuries to spaceflight crews. Such conditions as spatial disorientation, fluid shifts and endocrine changes which can decrease performance, cardiovascular tolerance, and possibly aggravate latent diseases, will be carefully evaluated to determine preventive measures. To this end, careful medical selection, periodic evaluation of health status, and in-flight monitoring of the time required for adaptation to the space environment will be continually undertaken. The supporting applied science element of the space medicine program is accomplished through a biomedical research program and seeks to develop the basic medical knowledge needed to enable men and women to operate more effectively in space. The program is organized into discrete elements, each designed to rectify a particular physiological problem known or expected to affect the human organism in space. Such problems as motion sickness, bone loss, and electrolyte imbalances are under intense scrutiny not only to provide a better understanding of their underlying causes, but also to develop more effective preventive measures. The program will make extensive use of ground-based simulation techniques which evoke, in both humans and animals, physiological changes similar to those seen in space.

The Advanced Life Support Systems research program concentrates on enhancing our ability to support a long-duration manned presence in space and optimizing the productivity of the Space Transportation System (STS) crews. Improvements are sought in spacecraft habitability and man-machine system engineering methods as well as a means to provide air, water, and food to support life directly. The program has developed technology for building apparatus to regenerate spacecraft air and water supplies in flight and is investigating the scientific basis for new systems such as food recycling for long-term missions. Research is in progress on space suits for quick reaction situations and on innovative approaches to designing space tools and work stations.

The Gravitational Biology program explores the role of gravity in life processes and uses gravity as an environmental tool to investigate fundamental biological questions. Specific objectives are to: (1) investigate and identify the role of gravity in plant and animal behavior, morphology and physiology; (2) identify the mechanisms of gravity sensing and the transmission of this information within both plants and animals; (3) identify the interactive effects of gravity and other stimuli (e.g., light) and stresses (e.g., vibration and disorientation) on the development and metabolism of organisms; (4) use gravity to study the normal nature and properties of living organisms; and (5) extend the limits of knowledge about plant and animal growth as well as long-term survival and reproduction in space.

The Exobiology program is directed toward understanding the origin and evolution of life, and life-related molecules, on Earth and throughout the universe. Research encompasses the cosmic history of the biogenic elements, prebiotic chemistry, early evolution of life, and evolution of advanced life. Understanding these processes in the context of the planetary and astrophysical environments in which they occurred will be emphasized. Flight experiments on planetary missions and in Earth orbit are important program elements. Theoretical and laboratory investigations are also included in this program to develop a better understanding of the conditions on Earth as related to early chemical and biological evolution.

The Biospheric Research program explores the interaction between the biota and the contemporary environment to develop an understanding of global bio-geochemical cycles. Laboratory and field investigations are correlated with remote sensing data to characterize the influence of biological processes in global dynamics. Biospheric modelling efforts are focused on integrating biology with atmospheric, climate, oceanic, terrestrial, and bio-geochemical cycling data to reflect the state of the biosphere as a function of both natural and anthropogenic perturbations.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $2.7 million in FY 1986 is due to a directed $4.0 million Congressional reduction which was partially offset by reallocations from other programs. The reduction will be accomplished by a general decrease in the level of activity.

BASIS OF FY 1987 ESTIMATE

The Space Medicine program will collect information on occupational exposures in zero-gravity on each Shuttle flight; conduct inflight clinical testing of countermeasures, especially in the areas of cardiovascular deconditioning, vestibular problems and muscle atrophy. The program will also develop health care procedures, equipment, and facilities compatible with the space environment. Medical selection standards will continue to be reviewed with an aim of gradually making space flight opportunities available to more of our population. The biomedical research element will begin to expand its research on physiological changes associated with longer exposure to weightlessness. Bone demineralization, muscle atrophy and cardiovascular deconditioning will be studied so that appropriate countermeasures can be devised. At the same time, problems associated with the initial adaptation to weightlessness, such as vestibular dysfunction and fluid shifts, will continue to be vigorously investigated. Furthermore, increased emphasis will be placed on radiation biology so that it will be possible to precisely measure dosages and effects of cosmic and solar radiation. This information will be required to determine the proper radiation shielding of humans in space. The performance and efficiency of flight crews will be emphasized by research of psychology and human factors.

The Advanced Life Support Systems program will continue to investigate basic biological processes and physical methods to control the interior environments of manned spacecraft; and will continue development of data acquistion systems and computer technologies to analyze and simulate human physical activities. Laboratory plant growth methods developed in recent years will be scaled up to obtain a capability to produce plant material at efficiency and productivity levels high enough for space life support applications.

The Gravitational Biology program will focus on expanding the investigation of plant and animal gravity sensing systems and gravitational affects on plant and animal reproduction and development. Research which leads to or includes space flight experiments will be emphasized with the objective of resolving discrete biological problems.

The Exobiology program will emphasize the development of new flight experiment concepts to clarify the non-biological mechanisms for the synthesis of biologically significant molecules in space, and completing definition of systems required before a search for extraterrestrial life can be initiated. These concepts will be crucial to our understanding of the origin of life on earth as well as assessing the possibility of these processes occurring elsewhere in the universe.

The Biospheric Research program will place emphasis on improving our estimating techniques for determining the functional and structural state of the terrestrial biomass by combining ground-based measurements with remote sensing data. Additional emphasis will be placed on characterizing biogenic gas fluxes of key atmospheric constituents. This information is required for the development of a better understanding of global bio-geochemical cycles.

Emphasis will also be placed on the formulation of improved approaches to the operational management of space adaptation syndrome. In-flight evaluation of these approaches will be conducted to provide the basis for the development of more effective countermeasures. There will be an expanded interdisciplinary approach to determining how to enhance the capabilities, performance and efficiency of spaceflight crews. The object of this effort will be to allow humans, to the fullest extent possible, the opportunity to explore and work in space by improving the working environment and by facilitation of the human interaction with the automated devices that can be placed at their disposal.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS **PLANETARY EXPLORATION PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Galileo development....................	58,800	39,700	54,200	---	RD 5-5
Magellan (VRM).........................	92,500	112,000	109,300	66,700	RD 5-7
Ulysses (ISPM).........................	9,000	5,600	5,600	---	RD 5-9
Mars Observer (MGCO)...................	13,000	43,800	37,800	62,900	RD 5-11
Mission operations and data analysis..	56,100	95,000	83,000	130,200	RD 5-13
Research and analysis..................	61,500	62,900	62,900	63,500	RD 5-15
Total..............................	290,900	359,000	352,800	323,300	

Distribution of Program Amount by Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Johnson Space Center...................	10,482	11,105	10,770	10,873
Marshall Space Flight Center...........	16	100	11	8
Goddard Space Flight Center............	3,751	3,620	5,601	11,884
Jet Propulsion Laboratory..............	225,878	284,755	284,262	249,734
Ames Research Center...................	8,593	10,159	9,478	10,462
Langley Research Center................	25	---	26	26
Headquarters...........................	42,155	49,261	42,652	40,313
Total..............................	290,900	359,000	352,800	323,300

PROGRAM OBJECTIVES AND JUSTIFICATION

The Planetary Exploration program encompasses the scientific exploration of the solar system including the planets and their satellites, comets and asteroids, and the interplanetary medium. The program objectives are: (1) to determine the nature of planets, comets, and asteroids as a means for understanding the origin and evolution of the solar system; (2) to understand the Earth better through comparative studies with the other planets; (3) to understand how the appearance of life in the solar system is related to the chemical history of the solar system; and, (4) to provide a scientific basis for the future use of resources available in near-Earth space. Projects undertaken in the past have been highly successful. The strategy that has been adopted calls for a balanced emphasis on the Earth-like inner planets, the giant gaseous outer planets, and the small bodies (comets and asteroids). Missions to these bodies start at the level of reconnaissance to achieve a fundamental characterization of the bodies, and then proceed to levels of more detailed study.

The reconnaissance phase of inner planet exploration, which began in the 1960's, is now virtually completed, although we still know little about the nature of the planet Venus' surface. Mars has provided program focus because of its potential as a site of biological activity. The Viking landings in 1976 carried the exploration of Mars forward to a high level of scientific and technological achievement, thereby setting the stage for the next step of detailed study. Analyses of meteorites and the lunar rock samples returned by Apollo continue to be highly productive, producing new insights into the early history of the inner solar system and thus leading to revision of our theoretical concepts. The Pioneer Venus mission is continuing to carry the study of the Earth's nearest planetary neighbor and closest planetary analog beyond the reconnaissance stage to the point where we have now obtained a basic characterization of Venus' thick, massive atmosphere, as well as fundamental data about the formation of the planet.

The exploration of the giant outer planets began relatively recently. The Pioneer-10 missions to Jupiter in 1973 and 1974 were followed by the Voyager-1 and 2 spacecraft encounters in 1979. Voyager-1 then encountered Saturn in November 1980, and Voyager-2 in August 1981. The Voyager data on these planets, their satellites, and their rings have revolutionized our concepts about the formation and evolution of the solar system. Voyager-2 encountered Uranus in January 1986 and has provided our first look at this giant outer planet. Its trajectory will then carry it to an encounter with the planet Neptune in 1989. The Pioneer-10 and 11 and Voyager-1 spacecraft are on trajectories heading out of the solar system, as they continue to return scientific data about the outer reaches of the solar system.

The Galileo orbiter/probe mission to Jupiter will be launched in May 1986 by the Space Shuttle/Centaur Upper Stage. The comprehensive science payload will extend our knowledge of Jupiter and its system of satellites well beyond the profound discoveries of the preceding Voyager and Pioneer missions. During twenty-two months of operation in the Jovian system, Galileo will inject an instrumented probe into Jupiter's atmosphere to make direct analyses, while the orbiter will have the capability to make as many as ten close encounters with the Galilean satellites.

Ulysses is a joint NASA and European Space Agency activity. The mission will carry a package of experiments to investigate the Sun at high solar latitudes that cannot be studied from the Earth's orbit. Ulysses will also be launched in May 1986 on the Shuttle/Centaur Upper Stage.

Magellan, formerly the Venus Radar Mapper mission, will provide global maps of the cloud-shrouded surface of Venus, including its land forms and geological features. Using a synthetic aperture radar to penetrate the planet's opaque atmosphere, Magellan will achieve a resolution sufficient to identify small-scale features and to address fundamental questions about the origin and evolution of the planet. Magellan will also obtain altimetry and gravity data to determine accurately the planet's gravity field as well as internal stresses and density variations. With these data, the evolutionary history of Venus can be compared with that of the Earth. Magellan is scheduled for launch in 1988 from the Shuttle and will use a Shuttle/Centaur Upper Stage.

Mars Observer will follow up on the earlier discoveries of Mariner 9 and Viking and will emphasize the geologic and climatic evolution of this complex planet. Mars Observer will be a relatively low-cost mission utilizing a modified Earth-orbiting spacecraft, thereby benefitting from aerospace industry's earlier investment in development.

This past year we entered an exciting new phase of exploration by making our first close-up studies of the solar system's mysterious small bodies -- comets and asteroids. These objects may represent unaltered original solar system material, preserved from the geological and chemical changes that have taken place in even small planetary bodies. By sampling and studying comets and asteroids, we can begin to make vigorous inquiries into the origin of the solar system itself. These efforts began with the encounter of Comet Giacobini-Zinner by the International Comet Explorer (ICE) spacecraft in September 1985 and are continuing through our involvement with the 1986 encounters of Comet Halley by

U.S. and foreign spacecraft and by intensive studies of the comet from ground-based observatories coordinated through the International Halley Watch. In addition, we are continuing to study a Comet Rendezvous/Asteroid Flyby (CRAF) mission in which a Mariner Mark II spacecraft would make long-term observations of an active comet, together with a close flyby of an asteroid.

The Planetary Exploration program is also founded on a coordinated research and analysis effort. Research and analysis activities will continue to maximize the scientific return from both ongoing and future missions and from such Earth-based activities as lunar sample and meteorite analysis, telescope observations, theoretical and laboratory studies, and instrument definition. This program strives for interdisciplinary coordination among various research groups and for the wide dissemination of scientific results. A close coupling is also maintained between the research programs and planning activities that are undertaken to define the scientific rationale and technology needed for future missions.

BASIS OF FY 1987 FUNDING REQUIREMENT

GALILEO DEVELOPMENT

(Thousands of Dollars)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Spacecraft............................	27,745	13,800	24,300	---
Experiments...........................	10,275	7,900	9,300	---
Ground Operations.....................	20,780	18,000	20,600	---
Total.................................	58,800	39,700	54,200	---
Space transportation system operations	(36,600)	(44,200)	(41,100)	(---)

OBJECTIVES AND STATUS

The objective of the Galileo program is to conduct a comprehensive exploration of Jupiter, its atmosphere, magnetosphere, and satellites through the use of both remote sensing by an orbiter and _in situ_ measurements by an atmospheric probe. The scientific objectives of the mission are based on recommendations by the National Academy of Sciences to provide continuity, balance, and orderly progression of the exploration of the solar system.

The orbiter and probe will be launched together in May 1986 as a single combined payload using the Shuttle/Centaur Upper Stage. The mission plan includes an option for an encounter with the asteroid Amphitrite, a large (200km) main belt asteroid, in late 1986. The decision to implement the option will be made after launch, based on an assessment of the health and operational capability of the spacecraft. Subsequently, arrival at Jupiter will be in late 1988 when the orbiter will provide remote sensing of the probe entry site and provide the link for relaying the probe data back to Earth. Twenty-two months of orbital operations will follow during which both Jupiter's surface and the dynamic magnetosphere will be comprehensively mapped. During this time ten close flybys of Jupiter's major satellites are targeted.

The Galileo flight system will be powered by two general purpose heat-source Radioisotope Themoelectric Generators (RTG's) being developed by the Department of Energy. The orbiter will carry approximately 100 kg of scientific instruments and the Probe will carry approximately 25 kg of scientific instruments.

During FY 1986, major activities of the Galileo program will include completion of testing and pre-launch acivities at JPL, retrofit of selected subsystems with more radiation resistant electronic components, and pre-launch and launch activities at the Kennedy Space Center in support of the May 1986 launch.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The FY 1986 estimate reflects an increase of $14.5 million, the result of problems with the spin bearing assembly and changeout of the radiation-hardened parts on the Command and Data Subsystem and Attitude Articulation and Control Subsystem. The additional funds were made available through transfer from Galileo Mission Operations and Data Analysis ($9.5M); and by rephasing of Magellan (VRM) activity ($2.5M) and Voyager Extended Mission activity ($2.5M) to future years.

BASIS OF FY 1987 FUNDING REQUIREMENTS

MAGELLAN (FORMERLY VENUS RADAR MAPPER MISSION)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Spacecraft............................	64,325	75,800	66,400	24,800
Experiments...........................	25,995	29,800	32,300	23,100
Ground Operations.....................	2,180	6,400	10,600	18,800
Total.................................	92,500	112,000	109,300	66,700
Space Transportation system operations	(28,400)	(27,500)	(39,500)	(47,800)

OBJECTIVES AND STATUS

The objective of the Magellan mission is to address fundamental questions regarding the origin and evolution of Venus through global radar imagery of the planet. Magellan will also obtain altimetry and gravity data to accurately determine the planet's gravity field as well as internal stresses and density variations. The detailed surface morphology of Venus will be analyzed to compare the evolutionary history of Venus with that of the Earth.

The Magellan spacecraft will carry a single major scientific instrument, a synthetic aperture radar, which will be used to obtain high resolution (120 to 200 meter) images of the planetary surface as well as altimetric data. Gravity data will be obtained by processing radio signals from the spacecraft. Spacecraft development is making extensive use of existing designs, technology, and residual hardware; for example, the spacecraft will use a bus structure, large antenna, and propulsion components from the Voyager program. Spare flight computers and other equipment will be obtained from the Galileo program after the Galileo launch in 1986.

In April 1988, the Magellan spacecraft will be launched by the Shuttle/Centaur Upper Stage on a direct trajectory to Venus. Arriving at Venus in July 1988, the spacecraft will perform a retro-propulsive maneuver and enter a near-polar elliptical orbit. After an initial check-out period, the spacecraft will map the planet over a 243 day period (one Venus year).

During FY 1986, major activities will include completion of the design effort for the spacecraft, the radar instrument, and the mission operations system, and for the initiation of construction of the flight hardware. The major flight spacecraft subassemblies will be completed and delivered to the spacecraft contractor.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The $2.7 million decrease is associated with a rephasing of activity to future years. Of this amount, $2.5 million has been reallocated for Galileo development to help solve technical problems and the balance reflects the application of the general reduction directed by Congress for Research and Development contained in the HUD-Independent Agencies Appropriation Act, 1986 (P.L. 99-160). In addition, reallocation of the funds within the project has been made based on the contractors' development schedule requirements.

BASIS OF FY 1987 ESTIMATE

FY 1987 funds will provide for completion of the radar sensor and for the assembly, integration and testing of the spacecraft system. The development of the mission operations system will be continued.

BASIS OF FY 1987 FUNDING REQUIREMENT

ULYSSES (FORMERLY INTERNATIONAL SOLAR POLAR MISSION)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Spacecraft............................	5,765	700	700	---
Experiments...........................	1,120	2,200	2,200	---
Ground Operations.....................	2,115	2,700	2,700	---
Total................................	9,000	5,600	5,600	---
Space transportation system operations	(36,500)	(44,300)	(41,100)	(---)

OBJECTIVES AND STATUS

Ulysses is a joint mission of NASA and the European Space Agency (ESA). ESA is providing the spacecraft and some scientific instrumentation. The U.S. is providing the remaining scientific instrumentation, the launch, tracking support, and the Radioisotope Thermoelectric Power Generators (RTG). The mission is designed to obtain the first view of the Sun above and below the plane in which the planets orbit the Sun. The mission will study the relationship between the Sun and its magnetic field and particle emissions (solar wind and cosmic rays) as a function of solar latitude, to provide a better understanding of solar activity on the Earth's weather and climate. Ulysses will be launched in 1986 on the Shuttle/Centaur Upper Stage.

Ulyssee was restructured in FY 1981, from a two-spacecraft mission--one provided by the United States and one provided by ESA--to a single ESA spacecraft mission; however, the United States participation in the program remains substantial. NASA is developing five of the nine principal investigator instruments, and three of the four European investigations have U.S. co-investigators. During FY 1983, the U.S. flight instruments were delivered to the ESA spacecraft developer for integration and system testing. All spacecraft testing has been completed and the spacecraft is being partially disassembled for storage until launch.

Major activities during FY 1986 include supporting U.S. principal investigators in their mission planning and for supporting ESA in pre-launch and launch activities at the Kennedy Space Center in support of the May 1986 launch.

BASIS OF FY 1987 FUNDING REQUIREMENT

MARS OBSERVER MISSION (FORMERLY MARS GEOSCIENCE/CLIMATOLOGY ORBITER)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Spacecraft development................	2,010	28,600	22,400	33,100
Experiments..........................	8,705	4,300	13,800	26,600
Ground Operations....................	2,285	10,900	1,600	3,200
Total..............................	13,000	43,800	37,800	62,900
Space transporation system operations	(---)	(---)	(---)	(9,100)

OBJECTIVES AND STATUS

The Mars Observer mission is the first planetary mission utilizing a new low-cost approach to inner solar system mission exploration. This approach, which was recommended by the Solar System Exploration Committee, starts with a well defined and focused science objective and makes use of high-inheritance, modified production line Earth-orbital spacecraft. The objective of the Mars Observer mission is to extend and complement the data acquired by the Mariner and Viking missions by mapping the global surface composition, atmospheric structure and circulation, topography, figure, gravity and magnetic fields of Mars to determine the location of volatile reservoirs and characterize their interaction with the Martian environment.

The Mars Observer mission will be launched in 1990 using the Space Shuttle, and will be inserted into Martian orbit in 1991, where it will carry out geochemical, geophysical, and climatological mapping of the planet over a period of one Martian year which is approximately two Earth years.

In FY 1986, critical design reviews will be held for the instruments, as will the preliminary design review for the spacecraft. In addition, detailed design and fabrication of the spacecraft and instrument hardware will be initiated.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $6.0 million in the current estimate reflects Congressional direction contained in the FY 1986 NASA Authorization Act (P.L. 99-170) and the HUD-Independent Agencies Appropriation Act, 1986 (P.L. 99-160). This reduction has been accommodated by the rephasing of activity to future years. Current estimates have also been realigned to be in consonance with the procurement schedules for the spacecraft bus and for the science payload.

BASIS OF FY 1987 ESTIMATE

The FY 1987 funding is required for continuation of major fabrication efforts on both the instruments and the spacecraft, and for preparation for the critical design reviews for the flight system. Preliminary design reviews will be completed for all the instruments as well as for the mission operations development.

BASIS OF FY 1987 FUNDING REQUIREMENT

MISSION OPERATIONS AND DATA ANALYSIS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Galileo operations....................	---	20,000	10,500	48,000
Ulysses operations....................	---	2,000	2,300	5,300
Voyager extended mission..............	26,036	26,400	23,000	4,800
Pioneer programs......................	6,300	7,600	7,600	8,300
Voyager/Neptune mission...............	---	9,000	9,000	30,300
Planetary flight support..............	23,764	30,000	30,600	33,500
Total.................................	56,100	95,000	83,000	130,200

OBJECTIVES AND STATUS

The objectives of the mission operations and data analysis activities are in-flight operation of planetary spacecraft and the analysis of data from these missions. Currently, two major classes of planetary spacecraft are operating--the Pioneer and the Voyager spacecraft. The planetary flight support activities are those associated with the design and development of planetary flight operation systems, and other activities that support the mission control, tracking, telemetry, and command functions for all planetary spacecraft.

The two Voyager spacecraft are now traveling through the outer solar system on trajectories that will take them into interstellar space. Voyager 1 continues to provide data on the interplanetary medium in that distant part of the solar system. In January 1986, Voyager 2 made a close flyby of the planet Uranus, the first time this planet has ever been visited by a spacecraft. The observatory phase of this encounter, which began in November 1985, will include detailed observations of the planet, its rings, and moons. After the Uranus encounter is completed, the spacecraft will continue on to the planet Neptune, where, in 1989, it will provide us with our first close look at this distant planet.

Pioneers 10 and 11 will continue to explore the outermost solar system. Pioneer 10 will soon enter the unexplored region beyond Pluto where the Sun's influence is secondary to those of true interstellar space. These spacecraft will continue the search for gravitational evidence of a tenth planet. Pioneers 6-9 are still collecting information on the interplanetary magnetic field and solar wind as they orbit the Sun. In 1986, these spacecraft are being used to observe Comet Halley as it passes in their vicinity.

The Pioneer Venus orbiter continues to obtain data from Venus' atmosphere and magnetosphere. In late 1985, the spacecraft's spin axis was adjusted to allow ultraviolet observations of Comet Halley. The Pioneer Venus is the only spacecraft able to observe the Comet at its closest approach to the Sun and is providing critical enhancements to the data to be gathered by foreign spacecraft making observations at other points later in the Comet's orbit.

The planetary flight support activities include the procurement, operation and maintenance of mission operations and general purpose scientific and engineering computing capabilities at the Jet Propulsion Laboratory (JPL). In addition, the activity supports the development of the Space Flight Operations Center at JPL. This facility will be a versatile, cost-effective means for carrying out multi-mission data acquisition, telemetry, image processing, and commanding of planetary and orbital spacecraft.

FY 1986 funding is supporting several major activities in 1986 -- the Voyager 2 encounter with Uranus in January, and initial operations of the Galileo and Ulysses missions, which are scheduled for launch in May. Operational support for the Voyager and Pioneer operations is also being continued, as well as for the extension of the Voyager 2 mission to a 1989 encounter with the planet Neptune. Activities are also continuing in multimission support development activities.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The $12.0 million decrease was the result of a transfer of funds to Galileo development and was made available as a result of the rephasing of activity associated with Galileo Operations and Voyager Extended Mission to future years.

BASIS OF FY 1987 ESTIMATE

FY 1987 funding is required for the continued operation and data analysis activities in support of the Galileo, Ulysses, Voyager and Pioneer operations. Development activities will also be continued in FY 1987 on the Space Flight Operations Center at the Jet Propulsion Laboratory.

BASIS OF FY 1987 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Supporting research and technology....	45,100	46,000	46,000	47,400
Advanced programs.....................	9,500	10,100	10,100	10,100
Mars data analysis....................	3,100	2,800	2,800	2,900
Halley's comet co-investigations and watch..........................	3,800	4,000	4,000	3,100
Total..............................	61,500	62,900	62,900	63,500

OBJECTIVES AND STATUS

The research and analysis program consists of four elements required to (1) assure that data and samples returned from flight missions are fully exploited; (2) undertake complementary laboratory and theoretical efforts; (3) define science rationale and develop required technology to undertake future planetary missions; and (4) coordinate an International Halley's Comet Watch and provide co-investigator support to the European Space Agency's Giotto mission to Halley's Comet.

The supporting research and technology activity includes planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, and instrument definition.

The planetary astronomy activity includes all observations made by ground-based telescopes of solar system bodies excluding the Sun. Emphasis is on the outermost planets, comets and asteroids. Observations are made at a wide range of wavelengths from ultraviolet to radio. The rate of new discoveries continues to be high, and the data acquired is used both for basic research in support of planetary program objectives and for direct support of specific flight missions. The planetary astronomy funding also provides for the continued operation of the Infrared Telescope Facility in Hawaii.

The planetary atmospheres activity includes data analysis, laboratory, and theoretical efforts. The properties of other planetary atmospheres are amenable to measurement with planetary spacecraft and can aid us in better understanding our own weather and climate. Observations of the atmospheres of Venus, Jupiter and Saturn, acquired by Pioneer Venus and Voyager, have laid the basic observational groundwork for major advances in this field.

The planetary geology/geophysics activity is a broadly scoped program that includes the study of surface processes, structure, and history of solid components (including rings) of the solar system and investigation of the interior properties and processes of all solar system bodies, both solid and gaseous. This program emphasizes comparative studies to gain a fundamental understanding of the physical processes and laws which control the development and evolution of all planetary bodies, including the Earth. In this respect, data from the Magellan mission will be of crucial importance.

The planetary materials/geochemistry activity supports an active scientific effort to determine the chemistry, mineral composition, age, physical properties and other characteristics of solid material in the solar system through the study of returned lunar samples and meteorites and through laboratory and theoretical studies of appropriate geochemical problems. Extraterrestrial dust grains, collected for analysis, continue to yield new and otherwise unobtainable information about the solar system, and its early history. This program is coordinated with the lunar sample and meteorite research which is supported by other agencies such as the National Science Foundation. The operation of the Lunar Curatorial Facility is also supported by the planetary materials/geochemical funding.

The instrument definition activity is directed toward ensuring maximum scientific return from future missions by the definition and development of state-of-the-art scientific instrumentation which is optimized for such missions.

The objective of the advanced program activity is to provide planning and preparation for the systematic exploration of the solar system on a scientifically and technically sound basis. Prospective planetary missions are identified and defined through long-range studies; their technological and fiscal feasibility is evaluated, and their scientific merit is determined through interaction with the scientific community. The strategy for future solar system exploration has been developed by the Solar System Exploration Committee (SSEC), an advisory group, which has recommended a series of "low-cost" but scientifically important potential future missions.

The Mars Data Analysis activity continues to ensure that we capitalize on the wealth of data provided by Viking and earlier missions and that we are scientifically prepared for the next phase of Mars exploration, more specifically, the Mars Observer mission. While continuing to support a variety of scientific investigations, the major emphasis of this program will address the origin and evolution of Martian volatiles.

The International Halley's Comet Co-Investigations and Watch is capitalizing on observing Comet Halley in 1985-1986 by supporting co-investigators on the European Space Agency's (ESA) Giotto mission, and by conducting complementary remote sensing investigations using both Earth-orbiting and ground-based facilities. The ESA Giotto mission will fly by Halley's Comet in 1986. Concurrently, an observation program called the International Halley Watch, coordinated by the United States, will conduct world-wide scientific observations of the Comet Halley. The objectives of the Watch are: (1) to coordinate scientific observations of Comet Halley through its 1985-1986 apparition; (2) to promote the use of standardized instrumentation and observing techniques; (3) to help insure that data is properly documented and archived; and (4) to receive and distribute data to participating scientists.

BASIS OF FY 1987 ESTIMATE

During FY 1987, research efforts will continue in the areas of planetary astronomy, planetary atmospheres, planetary geology/geophysics, planetary materials/geochemistry, instrument definition, Mars data analysis, and in the development of required technology to undertake future missions. Ground telescope observations will provide data complementary to that obtained from the flight missions, with emphasis on the outermost planets, comets and asteroids. A variety of efforts will be pursued to improve our understanding of planetary atmospheres, including laboratory studies of reactions in deep planetary and tenuous cometary atmospheres. Geology/geophysics research will be directed, in FY 1987, at specific problems in understanding the various processes that have shaped planetary surfaces, as well as geological analyses and a cartography effort based on the Galilean and Saturnian satellite imaging data acquired by Voyager. Analysis of lunar samples, meteorites, and extraterrestrial dust particles will be continued in FY 1987 to determine their chemical and physical properties and thereby derive their origin and evolutionary history. Instrument definition for potential future missions will be also be continued in FY 1987.

The FY 1987 Halley's Comet Co-Investigations and Watch funding is required to continue support of U.S. co-investigators involved in the European Space Agency's Giotto mission who will be analyzing the data acquired from Halley's Comet flyby of Earth.

The FY 1987 funding is also required to continue operations of both the Infrared Telescope Facility and the Lunar Curatorial Facility.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS **SOLID EARTH OBSERVATIONS PROGRAM**

SUMMARY OF RESOURCE REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
	(Thousands of Dollars)				
Shuttle/Spacelab payloads............	12,100	23,100	23,100	21,600	RD 6-4
Geodynamics..........................	29,900	31,700	31,700	32,100	RD 6-6
Research and analysis................	15,600	20,100	20,100	20,400	RD 6-8
Total............................	57,600	74,900	74,900	74,100	

Distribution of Program Amount by Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Johnson Space Center..................	940	250	1,000	800
Marshall Space Flight Center..........	250	277	300	800
Goddard Space Flight Center...........	32,360	37,175	37,500	36,300
Jet Propulsion Laboratory.............	14,952	28,184	26,200	26,100
Ames Research Center..................	2,578	645	800	800
National Space Technology Laboratories	2,213	2,875	2,700	2,800
Headquarters..........................	4,307	5,494	6,400	6,500
Total............................	57,600	74,900	74,900	74,100

PROGRAM OBJECTIVES AND JUSTIFICATION

The objectives of the Solid Earth Observations Program are to understand the processes controlling the state of the land surface and the interior of the Earth as well as the interaction of the solid Earth with the atmosphere and the oceans. The Solid Earth Observations Program is an integral part of the overall NASA Earth Science and Applications effort to increase our understanding of the planet Earth through the study of its dynamics, the physical processes which affect its habitability, and its solar-terrestrial environment.

Specific land surface objectives include determination of the terrestrial landscape including the biosphere and the hydrosphere, and understanding the changes and change mechanisms that are occurring within that landscape. Studies of the cycling of key biogeochemical elements, interactions between the biosphere and the climatic system, and the composition and evolution of crustal rock sytems are essential to these objectives.

The geodynamics research objectives include determination of the movements and deformation of the Earth's crust, the processes which drive tectonic plates, the rotational dynamics of the Earth and its interactions with the atmosphere and oceans, the Earth's gravity and magnetic fields, and the interior structure and composition of the Earth. These objectives require precise measurements of crustal movements and Earth orientation over an extended period along with accurate knowledge of the variability of the Earth's geopotential fields.

The objective of the Shuttle/Spacelab payload development project is to develop, test and evaluate Earth-viewing remote sensing instruments and systems to obtain data for solid earth observations research. The Shuttle Imaging Radar, which was flown on the Shuttle in October, 1984, has demonstrated the utility of spaceborne imaging radar for geologic exploration. The Large Format Camera (LFC), required for high resolution mapping applications, was flown successfully on the Shuttle in 1984 and is presently under consideration for possible commercialization upon completion of the research and development phase. The next generation Shuttle Imaging Radar, involving use of SIR-B components and a multi-polarized, dual frequency instrument is under development for flight in the early 1990's. The imaging spectrometer and solid-state sensor research efforts will continue to focus on the development of such features as electronic scan, inherent geometric and spectral registration and programmable high spatial and spectral resolution.

BASIS OF FY 1987 FUNDING REQUIREMENT

SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Imaging radar program..................	6,100	13,400	14,400	13,000
Large format camera...................	400	---	500	200
Advanced spectrometer.................	5,600	9,700	8,200	8,400
Total..............................	12,100	23,100	23,100	21,600

OBJECTIVES AND STATUS

The objective of this program is to develop, test, and evaluate Earth-viewing remote sensing instruments and systems to obtain data for land remote sensing research.

Preparations are continuing for a reflight of the Large Format Camera (LFC) and the Shuttle Imaging Radar-B (SIR-B). The SIR-B will obtain a quantitative assessment of the effect of various radar viewing geometries on the mapping of surface texture and topographic features. The SIR-B instrumentation is based on an upgraded SIR-A instrument including the addition of a variable look angle antenna, digital data handling, and increased bandwidth and resolution. Data is recorded on-board and transmitted via the Tracking and Data Relay Satellite System (TDRSS). Following the reflight of SIR-B, use of the SIR-B components for use in building the next generation Shuttle Imaging Radar instrument will be reviewed. The SIR-C instrument will utilize multi-polarized, dual frequency sensor technology.

Advanced spectrometer technology development activities include fundamental research in remote sensing involving airborne and spaceborne imaging spectrometer instruments. The imaging spectrometer and linear array solid-state sensor research focuses on the development of such features as electronic scan, inherent geometric and spectral registration, and programmable high spatial and spectral resolution. The critical technology development and supporting research on the Shuttle Imaging Spectrometer Experiment (SISEX) and the linear array focal plane will continue.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The FY 1986 current estimate remains unchanged in total from the budget estimate, however funds have been provided from the previous Advanced Spectrometer estimate in order to provide funding for reflight activities under review in the Imaging Radar and Large Format Camera projects.

BASIS OF FY 1987 ESTIMATE

FY 1987 funding is required for reflight of the Large Format Camera and the Shuttle Imaging Radar-B (SIR-B) plus data analysis. FY 1987 funding is also required for continued development of SIR-C technology, and for advanced spectrometer activities including the development of the Shuttle Imaging Spectrometer Experiment.

BASIS OF FY 1987 FUNDING REQUIREMENTS

GEODYNAMICS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Crustal dynamics project..............	18,000	18,500	18,500	18,100
Laser network operations..............	8,000	8,500	8,500	8,600
Research and technique development....	3,900	4,700	4,700	5,400
Total..............................	29,900	31,700	31,700	32,100

OBJECTIVES AND STATUS

The objective of the Geodynamics program is to understand the origin, evolution, and current state of the solid Earth by measuring the movement and deformation of the tectonic plates and by measuring its rotational dynamics and potential fields. Laser ranging, microwave interferometry and the global positioning satellites are used to determine precise position locations. The global gravity and magnetic fields are determined from satellite observations.

Measurements over the past five years have provided experimental determination of the velocities of several of the major tectonic plates. Measurements of regional deformation across the San Andreas Fault continue to indicate a relative movement of the Pacific and North American Plate of about 6 cm per year. In addition, new measurements indicate that about 4 cm of this movement is occurring in Southern California. Measurements of polar motion and changes in the length of day have been correlated, to a high degree, with variations in the angular momentum and the inertial balance of the Earth's atmosphere due to high altitude winds. In 1982 the Earth's rotation was found to have slowed by five milliseconds due to the El Nino effect. The Earth's rotational dynamics are also influenced by motions of the Earth's core and the oceans. Models of the Earth's gravity field, derived from Laser Geodynamics Satellite (LAGEOS-1) data have provided the first evidence of gravity field variations. These variations are believed to be caused by continued relaxation of the crust following the last ice age and have confirmed estimates of the viscosity of the Earth's mantle layer. Analysis of the magnetic field, using data from Magsat has confirmed (within a few percent) the diameter of the Earth's outer core (determined by seismological measurements) and has provided new data on secular variations of the magnetic field.

BASIS OF FY 1987 ESTIMATE

In FY 1987, measurements of plate motion between North America and Europe will be continued in cooperation with NOAA and several European countries. Measurements of the motions of the Pacific Plate will also be continued in cooperation with DoD and Japan and will be extended to include China. In addition, regional crustal deformation measurements in the western North America will continue in FY 1986 in cooperation with NOAA, Canada and Mexico. Similar measurements will be initiated in Europe in cooperation with a consortium of 10 European, North African, and Mid-East countries. The Caribbean studies will be continued in FY 1987 and are expected to involve some eight countries by 1988.

LAGEOS-1 and other satellites will continue to be used in FY 1987 for studies of plate motion. NASA systems in the U.S., Pacific, South America, and Australia will be operated in cooperation with laser systems in 12 other countries. The joint LAGEOS-2 mission with Italy will be launched by the U. S. in 1987.

Theoretical studies of crustal motion, internal Earth structure and composition, and the modeling and interpretation of geopotential fields will be continued in FY 1987. In addition, system studies of a second magnetic field satellite for long-term measurements of the Earth's field, studies of geopotential research and laboratory development of room-temperature and cryogenic gravity gradiometer instrumentation will be continued in FY 1987.

BASIS OF FY 1987 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Biochemical processes..................	4,000	4,700	4,700	4,800
Geological processes...................	5,100	6,300	6,300	6,400
Hydrologic processes...................	2,900	5,100	5,100	5,100
Remote sensing science.................	3,600	4,000	4,000	4,100
Total..............................	15,600	20,100	20,100	20,400

OBJECTIVES AND STATUS

The major objectives of the Solid Earth Research and Analysis Program are to characterize the physical, geological and biological state of the Earth's surface, to explore its variation with time, to understand the processes which control its state and its interactions with the atmospheric and hydrologic systems.

Existing operational and research sensor systems are used to gather data on land surface properties and their variations. Observations are also conducted using experimental systems on airborne and space-based platforms. Theoretical models are formulated and validated using these observational systems, the resulting algorithms are used in the analysis of land surface properties and processes. Observational systems are used which operate in the visible, infrared and microwave regions of the spectrum, and both active and passive systems are used. Much of the emphasis is on quantification of changes to the land surface, whether it be from natural or anthropogenic causes.

The geologic processes program addresses the study of the evolution of the Earth's crust on a global basis with multispectral remote sensing techniques. The relative distribution of rock types, spectral properties of rocks, regional tectonics, rock weathering processes and geobotanical relationships are important research topics that are being addressed for many types of geologic environments. Multispectral remote sensing data analysis studies are supported by laboratory and field spectrometery and field mapping efforts to verify spectral properties and interactions.

Biochemical processes are studies through global and continental scale observation programs using operational satellite data products and analytical techniques developed for this purpose. Additionally, high spectral resolution studies are conducted using aircraft platforms and regional scale studies are conducted using the Landsat Thematic Mapper. The areal extent and temporal variability of ecosystems are investigated, and the causal mechanism sought.

CHANGES FROM FY 1986 BUDGET ESTIMATE

In FY 1986 $1.5 million will be applied to modifications on the Galileo replacement aircraft.

BASIS FOR FY 1987 ESTIMATE

In FY 1987 emphasis will be on investigations of the Earth's systems which are undergoing stress, in order to better understand the processes which control such systems. Specific regions will be identified for study, long-term observations will be initiated and data will be assembled from existing satellite data, and intensive field measurement programs will be defined. Pilot studies to validate methodologies will be conducted and global to regional scale process models will be developed and utilized for processing the data. A mixture of biomes and stress factors will be identified; initial emphasis will be on semi-arid to arid regions undergoing seasonal or multi-year drought and on forest biomes under stress from acid rain and conversion. The activities are closely associated with the International Satellite Land Surface Climatology Project (ISLSCP) and the International Global Change Program. A major field experiment will be conducted in 1987 under the auspices of ISLSCP and the World Climate Research Program.

The FY 1987 activities will also emphasize studies to determine continental rock type and erosion processes in semi-arid regions in sedimentary basins. Newly developed sensor systems such as the Advanced Visible-Infrared Imaging Spectrometer (AVIRIS), quad-polarization L- & C-Band imaging radar and the Thermal Visible-Infrared Imaging Spectrometer (TIMS) will be used in these investigations, and will serve as prototypes for shuttle instruments now under development and for future Space Station polar platform instruments. The thematic mapper on the operational Landsat will continue to serve as the focal instrument for multidisciplinary investigations, with particular emphasis on the tectonic structure of continental highlands.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS | ENVIRONMENTAL OBSERVATIONS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
	(Thousands of Dollars)				
Upper atmosphere research and analysis	31,000	33,000	33,000	33,400	RD 7-6
Atmospheric dynamics and radiation research and analysis...............	28,500	30,300	30,300	30,900	RD 7-8
Oceanic processes research and analysis............................	19,400	20,600	20,600	20,800	RD 7-11
Space physics/research and analysis...	16,700	17,800	17,800	18,000	RD 7-13
Payload and instrument development....	7,800	5,600	5,600	12,000	RD 7-15
Earth radiation budget experiment.....	8,100	2,000	2,000	---	RD 7-18
Extended mission operations...........	29,500	37,000	37,000	33,600	RD 7-19
Interdisciplinary research and analysis............................	1,000	1,000	1,000	1,100	RD 7-22
Tethered satellite payloads...........	3,000	4,500	4,500	1,000	RD 7-23
Scatterometer.........................	12,000	31,700	14,000	35,900	RD 7-25
Upper atmosphere research satellite mission............................	55,700	134,000	124,000	152,200	RD 7-27
Ocean topography experiment...........	---	---	---	29,000	RD 7-29
Total............................	212,700	317,500	289,800	367,900	

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Distribution of Program Amount by Installation				
Johnson Space Center..................	170	477	200	200
Marshall Space Flight Center..........	8,200	10,315	11,200	8,500
Goddard Space Flight Center...........	126,416	206,466	190,300	219,500
Jet Propulsion Laboratory.............	31,266	56,057	31,800	82,900
Ames Research Center..................	5,559	3,662	2,700	2,700
Langley Research Center...............	10,516	10,503	19,200	18,600
National Space Techonology Laboratories	60	237	100	100
Headquarters..........................	30,513	29,783	34,300	35,400
Total.............................	212,700	317,500	289,800	367,900

OFFICE OF SPACE SCIENCE AND APPLICATIONS — **ENVIRONMENTAL OBSERVATIONS PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATION

The objectives of the Environmental Observations program are to improve our understanding of the processes in the magnetosphere, atmosphere, and the oceans; to provide space observations of parameters involved in these processes; and to extend the national capabilities to predict environmental phenomena, both short and long term, and their interaction with human activities. Because many of these phenomena are global or regional, they can be most effectively, and sometimes only observed from space. NASA's programs include scientific research efforts plus the development of new technology for global and synoptic measurements. NASA's research satellites provide a unique view of the radiative, chemical, plasma acceleration, and dynamic processes occurring in the magnetosphere, atmosphere, and oceans.

To achieve these goals, a number of significant objectives have been established for the next decade. These include advancing the understanding of the upper atmosphere through the determination of the spatial and temporal distribution of ozone and select nitrogen, hydrogen, and chlorine species in the upper atmosphere and their sources in the lower atmosphere; optimizing the use of space-derived measurements in understanding large scale weather patterns; advancing our knowledge of severe storms and forecasting capabilities, ocean productivity, circulation, and air-sea interactions; improving the knowledge of seasonal climate variability leading to a long-term strategy for climate observation and prediction; and enabling a comprehensive understanding of solar terrestrial processes and a detailed determination of the physics and coupling between the solar wind, magnetosphere, ionosphere, and atmosphere.

Effective utilization of remote sensing requires a balanced set of activities including: analytical modeling and simulation; laboratory research of fundamental processes; development of instrumentation, flight of the instruments on the Space Shuttle and dedicated spacecraft; collection of _in situ_ ancillary or validation data; and scientific analysis of data. The approach is to develop a technological capability with a strong scientific base and then to collect appropriate data, through remote and _in situ_ means, which will address specific program objectives.

The Upper Atmospheric Research Satellite (UARS) will place a set of instruments in Earth orbit which will make comprehensive measurements of the state of the stratosphere, providing data about the

Earth's upper atmosphere in spatial and temporal dimensions which are presently unattainable. Detailed definition studies of the instruments have been completed, and the design and development activities are well underway. Development of the UARS observatory will continue in FY 1987.

The Earth Radiation Budget Satellite (ERBS) was successfully launched in 1984, and data continues to be collected from the satellite. The ERBE instruments which will be flown on NOAA-G have been completed. NOAA-F was launched December 12, 1984, with a set of ERBE instrumentation; the NOAA-G launch is scheduled for March 1986. NASA is also continuing to support the National Oceanic and Atmospheric Administration (NOAA) by managing the implementation of the polar orbiting NOAA and Geostationary Operational Environmental Satellites (GOES) series on a reimbursable basis.

Design and development activities are being continued in FY 1987 on a delayed basis on the NASA Scatterometer (NSCAT), which will be flown on the Navy Remote Ocean Sensing System (N-ROSS) in late 1990, to acquire global ocean data for operational and research use by both the military and civil sectors.

The Ocean Topography Experiment (TOPEX) is being proposed as a new start in FY 1987; its objective is to acquire precise observations of the surface topography of the oceans. These data, in conjunction with those from NSCAT, will enable the first determination of the wind forcing and ocean-current response of the global oceans.

The Nimbus spacecraft continues to collect unique data which is being used in the study of long term trends of the Earth's atmosphere, oceans and polar ice, and provides near real time data. Collection and analysis of Solar Mesosphere Explorer (SME) data, the only mesosphere data currently available, continues. The Dynamics Explorer spacecraft continues to collect valuable data on magnetosphere-ionosphere coupling processes. In addition, the International Sun Earth Explorer (ISEE-3) spacecraft, renamed International Cometary Explorer (ICE), has completed an exploration of the Earth's geomagnetic tail. On September 11, 1985, ICE accomplished the first encounter with a comet as it passed through the tail of Giacobini-Zinner. ICE will also provide supporting solar wind measurements for the March 1986 Halley missions. In March-May 1986, the Polar Region and Outer Magnetosphere International Study (PROMIS) will coordinate six satellites (ISEE 1 and 2, ICE, Active Magnetospheric Particle Explorer (AMPTE), Interplanetary Monitoring Platform (IMP-8), Dynamics Explorer (DE-1) and the Swedish Viking satellite to provide unique data on magnetospheric processes.

Shuttle payload and reflight activities, along with flight of opportunity instrument development efforts provide the spaceborne data necessary to conduct basic research projects as well as provide calibration, correlative, and developmental feasibility information for major free-flying spacecraft. Instrument activities include Shuttle payloads such as Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS), Active Cavity Radiometer (ACR), Light Detection and Ranging (LIDAR), and Space Plasma Physics flight of opportunity instruments such as those for the Japanese Geotail Spacecraft and the European Solar Heliospheric Observer (SOHO) spacecraft.

Along with the Solid Earth Observations program, the Environmental Observations activities compose an integral part of NASA's total Earth sciences and applications efforts, with emphasis on understanding the Earth as a planet, studying its dynamics, processes, habitability, and solar-terrestrial environment.

BASIS OF FY 1987 FUNDING REQUIREMENT

UPPER ATMOSPHERE RESEARCH AND ANALYSIS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Upper atmospheric research............	18,700	19,900	19,900	20,100
Stratospheric processes...............	6,400	6,800	6,800	6,900
Tropospheric chemistry................	5,900	6,300	6,300	6,400
Total..............................	31,000	33,000	33,000	33,400

OBJECTIVES AND STATUS

The upper atmosphere research program is a comprehensive research and technology effort designed to investigate and monitor the phenomena of the upper atmosphere and related phenomena in the lower atmosphere. It is aimed at improving our basic scientific understanding of the global atmosphere and the methods needed to assess its susceptibility to significant chemical and physical change. The program's three major thrusts are in the areas of upper atmospheric research, stratospheric processes research, and tropospheric chemistry research.

In particular, the goal of the upper atmosphere research program is to understand the physics, chemistry and transport processes in the stratosphere on a global scale, and to assess as accurately as possible the perturbations to the atmosphere caused by man's activities. In order to accomplish this, efforts are underway to: (1) improve upper atmosphere and global troposphere models, validate them, and assess their uncertainties; (2) measure important trace chemical constituents, temperature, and radiation fields throughout the atmosphere; (3) develop sensors capable of making chemical and physical measurements of the upper atmosphere and the global troposphere both directly and remotely from space; (4) assemble and maintain the existing long-term data base of stratospheric and tropospheric ozone measurements to aid in the detection of long-timescale natural variations and man-made ozone changes; (5) determine the effects of global tropospheric chemistry on the atmosphere; (6) conduct theoretical and field studies of tropospheric/stratospheric exchange; and (7) carry out laboratory kinetics and spectroscopy investigations to support these activities.

A variety of in situ and remote sensing techniques are needed to meet the objectives of determining and understanding the distribution of ozone and other trace species in the atmosphere. Data sets from a limited number of satellites are now generally available to the scientific community, including a record of the global distribution of ozone extending back over a decade, and simultaneous observations of a number of trace constituents. This data is being exploited to determine if trends in the ozone amount has been detected and to understand those processes which are directly involved with these trends.

CHANGES FROM FY 1986 BUDGET ESTIMATE

Although there is no change in total, in FY 1986, $1.4 million will be applied from benefitting research areas to modifications on the Galileo replacement aircraft.

BASIS OF FY 1987 ESTIMATE

Recent developments in our understanding of the ozone layer have revealed a possible non-linear dependence of ozone depletion on the amount of fluorocarbon released to the atmosphere. These findings place increased urgency on the need to verify the completeness and accuracy of the theoretical stratospheric models. In FY 1987, tests of the models will be continued by means of field measurements, model calculations, and interpretation of satellite data. The development of more realistic two- and three-dimensional models will be continued. The global data sets from past and present satellites will be further analyzed in FY 1987 to aid in the understanding of large-scale atmospheric processes.

The comparison of balloon, aircraft, and ground-based measurements will be continued in FY 1987 to ensure the validity of the different techniques that have been developed and to observe chemical species in the stratosphere and troposphere to determine the exchange of gases between the lower and upper atmosphere. These balloon and aircraft measurement programs are the only way to measure many of the localized phenomena of the atmosphere; they also help to validate satellite observations. Studies of potential new instruments for use on future satellites and suborbital measurement platforms will also be conducted in FY 1987 to ensure that new technologies are put to use in improving the capability and cost efficiency of tropospheric composition and upper atmosphere measurements.

BASIS OF FY 1987 FUNDING REQUIREMENT

ATMOSPHERIC DYNAMICS AND RADIATION RESEARCH AND ANALYSIS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Global-scale atmospheric processes research and analysis	13,400	14,200	14,200	14,400
Mesoscale atmospheric processes research and analysis	7,600	8,000	8,000	8,200
Climate research and analysis	7,500	8,100	8,100	8,300
Total	28,500	30,300	30,300	30,900

OBJECTIVES AND STATUS

The research and analysis activities within the Atmospheric Dynamics and Radiation program comprise a core effort which is fundamental to using space technology to solve problems in atmospheric science. The program's three main thrusts are in the areas of global-scale tropospheric processes research, mesoscale processes research and climate research.

The objectives of the global scale research program are to improve our understanding of large-scale atmospheric behavior and to develop improved capability to observe the atmosphere from space. The program involves the development of advanced remote sensing instrumentation to observe the atmosphere, the development of advanced analysis techniques to better utilize existing meteorological satellite data, and development of advanced numerical models which use satellite observations to describe the state of the atmosphere both diagnostically and predictively. Recent accomplishments include the development of techniques which more fully utilize passive multispectral data (IR and microwave) from the NOAA operational satellites to provide global maps of a number of key atmospheric and surface parameters. In addition, special attention has been devoted to developing active lidar techniques to provide detailed profiles of atmospheric temperature, pressure, and moisture data from future spaceborne platforms. Simulations of these advanced techniques indicate their increased potential in greatly improving meteorological prediction capability.

The objectives of the mesoscale processes research program are to improve our understanding of the behavior of the atmosphere on short (minutes to hours) time scales and over local to regional size scales (severe weather, such as tornadoes and hurricanes). Since the characteristic parameters of these mesoscale processes cannot be measured directly, new techniques are under study to derive the information from other observations which can be directly measured. Such an activity requires advanced data handling and analysis techniques which rely upon man-computer interactive display and manipulation. A joint NASA-NOAA project of this type was completed and is known as the Centralized Storm Information System. In the area of remote sensor development, successful flights of instrumentation on the ER-2 aircraft to observe cloud top dynamics have been completed, and a feasibility study of a potential lightning mapper has been completed. NASA is currently working with NOAA to determine the practical value of lightning mapping from geostationary orbit and the possibility of incorporating experimental lightning mapping observations on the GOES-Next spacecraft.

The Climate Research Program seeks to develop a space capability for global observations of climate parameters which will contribute to our understanding of the processes that influence climate and its predictability. Research is focused in accordance with the National Climate Program priorities wherein NASA has the role of lead agency for solar and Earth radiation research. Future study thrusts will be aligned with programs of solar irradiance monitoring, Earth radiation budget monitoring and analysis, the global distribution and effect of cloud systems and stratospheric aerosols on the radiation budget, and on selected process studies which relate to monitoring of climate change. The past year's activities have stressed data analysis and model studies of the effects of the El Chichon volcano on climate. The first results of the data phase of the International Satellite Cloud Climatology Project (ISCCP) have been successfully archived and detailed planning for the First ISCCP Regional Experiment (FIRE) has been completed through a national project office located within NASA. Data from ISCCP and FIRE will be analyzed in conjunction with the Earth Radiation Budget Experiment (ERBE) data to improve our knowledge of cloud-radiation interactions which affect our climate. In addition, measurements of the solar irradiance will continue through the repaired Solar Maximum Mission (SMM) spacecraft, Nimbus 7 and reflights of the Active Cavity Radiometer flown on Spacelab-1.

CHANGES FROM FY 1986 BUDGET ESTIMATE

Although there is no change in total, in FY 1986 $1.4 million will be applied from benefitting research areas to modifications on the Galileo replacement aircraft.

BASIS OF FY 1987 ESTIMATE

FY 1987 funding is required to conduct aircraft flights to study the detail of flows around thunderstorms and fronts, continue comparison of models, study atmospheric scale interactions, and develop techniques to display model outputs in 3-dimensions. In FY 1987 three major interagency field experiments will significantly improve our understanding of the atmosphere for air/ocean interaction which generate crippling New England snowstorms (GALE), the physics of small strong downdrafts called microbursts which are on the scale of tornadoes (MIST), and the mechanism of regional precipitation quantification (SPACE) through space, aircraft, radar balloon, and surface-based observations. Other activities will involve continued retrieval and archiving of global International Satellite Cloud Climatology Project data sets, analysis of data from the Earth Radiation Budget Experiment and the Stratospheric Aerosol and Gas Experiment, and continued ground-based and rocket flight support for solar irradiance monitoring. Technology development of active temperature, pressure, and moisture sounders as well as basic lidar technology development will also be continued in FY 1987.

BASIS OF FY 1987 FUNDING REQUIREMENT

OCEANIC PROCESSES RESEARCH AND ANALYSIS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Research and analysis.................	19,400	20,600	20,600	20,800

OBJECTIVES AND STATUS

The Oceanic Processes Research and Analysis (R&A) program emphasizes the development and application of spaceborne observing techniques to advance our understanding of the fundamental behavior of the oceans, as well as to assist users with the implementation of operational systems. As such, the program operates in concert with a variety of federal agencies (e.g., Navy, NOAA, NSF) and foreign countries (e.g., Canada, Europe, Japan).

The Oceanic Processes R&A program is organized into three discipline areas: (1) physical, (2) biological, and (3) polar oceanography. The spaceborne observational technique of prime importance, and its corresponding scientific use for each area are as follows. In physical oceanography, satellite scatterometers and altimeters are used to observe surface roughness and topography, from which surface winds and ocean current response can be estimated. In biological oceanography, color scanners are used to observe chlorophyll concentration, from which primary productivity can be estimated. In polar oceanography, microwave radiometers and synthetic aperture radars are used to estimate the characteristics of sea-ice cover and the details of its motion.

The Oceanic Process R&A program is actively pursuing scientific research with other federal agencies and foreign countries for the World Climate Research Program (WCRP). Component WCRP efforts include the Tropical Ocean/Global Atmosphere (TOGA) and World Ocean Circulation Experiments (WOCE), a Global Flux Experiment (GFE), and a Program for International Polar Oceans Research (PIPOR).

CHANGES FROM FY 1986 BUDGET ESTIMATE

In FY 1986 $.3 million will be reallocated from benefitting research areas to modifictions on the Galileo replacement aircraft.

BASIS OF FY 1987 ESTIMATE

In FY 1987, the physical oceanography research activities will include implementation planning for WOCE and TOGA, as well as the development of numerical models and associated data assimilation techniques for use in determining the general circulation of the oceans. In biological oceanography, the analysis of data from Nimbus-7 will be continued in order to estimate global ocean productivity, as well as to help with the conceptual design of the Global Flux Experiment. In addition, accommodation studies for potential flight of an Ocean Color Imager for the NOAA-K spacecraft will be performed. In polar oceanography, emphasis will be placed on the experimental design for the Program for International Polar Oceans Research, which is planned to involve direct reception in Alaska of SAR data from the European Space Agency's ERS-1 and from the Japanese JERS-1 spacecraft due for launch in the 1989 - 1991 time frame. With the transition of the Pilot Ocean Data System from a technical demonstration to a scientific support facility completed in FY 1986, coordination activities with the Office of Naval Research, NSF, and NOAA will be pursued in order to assure that appropriate computing facilities and data archives will be available for the utilization of spaceborne observations from ocean-research missions planned within the next decade.

Advanced technology development activities will also be continued on prospective future sensors for flight aboard both the Shuttle and free-flying spacecraft.

BASIS OF FY 1987 FUNDING REQUIREMENT

SPACE PHYSICS RESEARCH AND ANALYSIS

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Plasma physics SR&T and data analysis	10,500	12,300	10,600	12,300
Advanced technology development.......	2,900	2,000	3,800	2,100
Solar terrestrial theory..............	3,300	3,500	3,400	3,600
Total.............................	16,700	17,800	17,800	18,000

OBJECTIVES AND STATUS

Space physics research and analysis is a broadly structured effort to enhance our understanding of the characteristics and behavior of plasmas in the solar corona, the interplanetary medium and in the vicinity of the Earth and other planets. These studies include: the complex coupling of the atmosphere with the ionosphere and the magnetosphere; the solar wind and how it interacts with planetary magnetospheres and ionospheres; and how variations in the solar wind are coupled into the near planetary environment and neutral atmosphere. This discipline also includes the conduct of active experiments to extract information under controlled conditions, and the use of space as a laboratory for the study of plasmas in parameter regimes that are unattainable on the Earth. The understanding of the plasmas in the solar system, the only naturally occurring plasmas to which we have direct access, will also enable us to refine theories regarding astrophysical plasma processes.

The major thrust of the space physics program is directed at studies of the near Earth environment, from the flow of the solar wind past the magnetosphere, to manifestations of variations of the plasma environment detectable near the surface of the Earth. Not only are these studies of great interest to the Earth sciences community, but also there are other practical components concerned with these aspects, such as ionospheric influences on communication, global circulation of the atmosphere driven by magnetospheric input, the charging of spacecraft immersed in plasma, and the behavior of antennas and their signals in the magnetosphere.

This field of research is one of relative maturity, with emphasis on multipoint, in situ measurements and on active perturbation experiments rather than isolated exploratory observations. For example, there are presently four spacecraft systems--the Interplanetary Monitoring Platform, the International Sun-Earth Explorer (ISEE), Dynamics Explorer, and the Active Particle Tracer Explorers (AMPTE) taking such measurements. AMPTE has carried out a program of coordinated chemical releases and plasma diagnostics to investigate solar wind plasma entry into the magnetosphere and energization as the plasma flows towards the atmosphere. The campaign called PROMIS (Polar Region and Outer Magnetosphere International Study) will take full advantage of these satellite systems during March-May 1986 when the Swedish Viking satellite contributes toward a unique opportunity for correlative measurements of the Earth's magnetosphere on a large scale. There is an active program of sounding rocket and balloon investigations aimed principally at spatially or temporally isolated atmospheric, ionospheric or magnetospheric phenomena. Active theoretical, modeling and supporting laboratory activities are also being conducted.

The solar terrestrial theory activity continues to provide a strong basis for all of the programs in both solar physics and space plasma physics. Theoretical groups are engaged in research on virtually every aspect of the solar terrestrial problem by using both fundamental process calculations and numerical models of large scale phenomena.

CHANGES FROM FY 1986 BUDGET ESTIMATE

In total, the FY 1986 current estimate remains the same as the budget estimate. However, within the program, $1.8 million has been transferred to ATD activities to enhance Solar-terrestrial instrument development.

BASIS OF FY 1987 ESTIMATE

During FY 1987, the space physics research and analysis activities will be continued with particular emphasis on the analysis of data obtained from the 1986 PROMIS campaign and from the International Cometary Explorer (ICE) which collected unique data in the earth's distant magnetotail before going on to an encounter with the comet Giacobini-Zinner in September 1985. Definition studies will be continued during FY 1987 on such missions as the potential cooperative solar terrestrial research with the Japanese and Europeans, follow-on missions for the U.S.-Italian Tethered Satellite System, and on the chemical release investigations in support to the Combined Chemical Release and Radiation Effects Satellite (CRRES) which is being developed by the Department of Defense.

The solar terrestrial theory program will be continued during FY 1987. In addition, a comprehensive and quantitative aggregate model of solar-terrestrial interaction will continue to be developed.

BASIS OF FY 1987 FUNDING REQUIREMENT

PAYLOAD AND INSTRUMENT DEVELOPMENT (ENVIRONMENTAL OBSERVATIONS)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Measurement of Air Pollution from Satellites (MAPS)....................	700	500	500	800
Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS).............	2,600	1,800	1,600	2,400
Active Cavity Radiometer (ACR, ACRIM)	1,800	900	1,100	1,000
Light Detection and Ranging (LIDAR)...	2,500	1,600	1,800	2,600
Principal investigator instrument development and reflight program....	200	800	600	200
Solar terrestrial instrument development........................	(2,900)*	(2,000)*	(3,800)*	5,000
Total..............................	7,800	5,600	5,600	12,000

*Non-add previously funded under Space Physics Research and Analysis.

OBJECTIVES AND STATUS

The Space Transportation System offers the unique opportunity for frequent short-duration flights of instruments. The Environmental Observations program has incorporated this capability into the Shuttle/Spacelab payload development activities in these important aspects: early test, checkout and design of remote sensing instruments for long duration free-flying missions; and short-term atmospheric and environmental data gathering for basic research and analysis where long-term observations are impractical.

The Measurement of Air Pollution from Satellites (MAPS) experiment is a gas-filter correlation radiometer designed to measure the levels of tropospheric carbon monoxide and the extent of interhemispheric mass transport in the lower atmosphere. The instrument was flown successfully on two

Shuttle flights. It is approved for four flights, one for each season of the year to provide the first observations of the global seasonal variation of carbon monoxide in the Earth's atmosphere. Reflight of MAPS is planned on both SRL-2 (Shuttle Radar Lab) and EOM 4 (Earth Observations Mission).

The objective of the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS) experiment is to make detailed measurements of gaseous constituents (e.g., hydrogen chloride, water, ammonia, methane) in the Earth's atmosphere by using the technique of infrared absorption spectroscopy. The data will help determine the compositional structure of the upper atmosphere, including the ozone layer and its spatial variability on a global scale. The instrument was launched in 1985 on Spacelab-3; it will be reflown on the Earth Observation Mission (EOM) series starting in 1986. The science results from the first flight of ATMOS were of exceptional value, and the basic capability of ATMOS to measure very low concentrations of trace species in the earth's atmosphere was clearly demonstrated.

In response to an Announcement of Opportunity, a number of principal investigator class instruments were selected for development. Payloads currently under development include the Active Cavity Radiometer-I (ACR-1) which is designed to aid in the study of the Earth's climate and the physical behavior of the Sun. Reflights of ACR-1 on future EOM flights are planned. Other experiments have also been selected for reflight, including some instruments which were flown on the Shuttle orbital flight tests, Spacelab 1 and Spacelab 2.

Solar-terrestrial instrument development activities will provide state-of-the-art instrumentation for flight opportunities on international spacecraft and various U.S. spacecraft of opportunity including those of other U.S. agencies and the Space Shuttle. The emphasis is on developing scientific instruments that have been conceived through the Space Plasma and Solar Physics Research and Analysis programs and through the Sounding Rocket program. The development and selection of opportunities will be coordinated and focused to answer questions identified in the National Academy of Sciences Committee on Solar and Space Physics report on Priorities in Solar-System Space Physics. Most of the instruments developed through this program will provide a U.S. contribution to an international thrust in Solar-Terrestrial research in the 1989-1995 timeframe.

Discussions are continuing with other U.S. agencies--the USAF Air Weather Service, the DOD Space Test Program (STP) and NOAA--about joint missions to characterize solar activity, the solar wind and the reaction of the earth's environment as source measurements.

CHANGES TO FY 1986 BUDGET ESTIMATE

The FY 1986 current estimate remains unchanged from the budget estimate in total; however there has been some transfer of funds within the Shuttle/Spacelab Payload elements to allow for an increase in the LIDAR development and the provision of funding for ACR reflight.

BASIS OF FY 1987 ESTIMATE

FY 1987 funds will be used to support the Measurement of Air Pollution from Satellites (MAPS) science team activities including data reduction, refurbishment for reflight and upgrading of the ground service equipment.

The initial flight of the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS) instrument was completed in 1985, with greater than expected science results. The FY 1987 funding is required to support the reflights of ATMOS which includes continued science team activities, data processing and analysis, post- and pre-flight calibration and limited refurbishments.

FY 1987 funding is also required to continue the Active Cavity Radiometer (ACR) data processing, science team activities, and refurbishment for reflight on future Shuttle EOM flights, and development of a free-flyer version of ACR. The principal investigator instrument development and reflight program will be continued with research efforts concentrated on atmospheric chemistry, solar intensity and variability, and upper atmospheric winds.

Development activities will continue on the international (U.S. and French) Light Detection and Ranging (LIDAR) instrumentation following completion of conceptual definition, breadboard laboratory activities, and preliminary design reviews. In this advanced state-of-the-technology program, both NASA and the French are supplying science knowledge and hardware to demonstrate first-time detail measurements of the atmosphere to aid in forecasting.

In FY 1987, Solar Terrestrial Instrument Development will begin with increased efforts focusing on continued activities with the Japanese Institute for Space and Astronautical Sciences (ISAS) for a mission to explore the earth's geotail. While ISAS will provide the Geotail Spacecraft and the majority of the instruments, NASA will provide instruments requiring unique capabilities to measure the hot, low density plasmas, energetic plasmas, low intensity waves and weak magnetic fields in the deep magnetic tail. In addition, the European Space Agency (ESA) and NASA will continue planning a joint solar-terrestrial research effort to make detailed measurements of solar variability and solar oscillations, the origin and flow of the solar wind, the interaction of the solar wind with the terrestrial magnetosphere, and the resultant space plasma microprocesses. ESA will provide the SOHO and CLUSTER satellites, and the majority of the instruments. NASA will provide instruments for solar oscillations and solar corona measurements and several space plasma instruments that are unique in their capabilities and performance.

BASIS OF FY 1987 FUNDING REQUIREMENT

EARTH RADIATION BUDGET EXPERIMENT

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Earth radiation budget experiment.....	8,100	2,000	2,000	---

OBJECTIVES AND STATUS

The objective of the Earth Radiation Budget Experiment (ERBE) is to measure the temporal and spatial variations in the Earth's radiation budget to gain basic insight into the causes for climatic fluctuations.

Initial experimental Earth radiation budget instruments were flown on the Nimbus satellites. Sampling studies based on those experiments have shown that adequate global coverage requires a multiple satellite system. These studies also indicate the need for improved calibration of the sensors and measurements covering full seasonal cycles. In order to provide adequate and meaningful coverage, identical Earth radiation budget instruments have been installed on the NOAA-F and NOAA-G satellites and on one dedicated NASA observatory (ERBS). The scientific objectives and measurement requirements were developed by a combined NOAA/NASA/university/industry team of scientists and recommendations of the National Academy of Sciences.

In addition to the ERBE instruments, the NASA observatory carries the Stratospheric Aerosol and Gas Experiment (SAGE II) which provides stratosphere aerosol data.

The ERBS spacecraft was launched by the Space Shuttle to an altitude of 300 km and then propelled to the operational altitude of 610 km by an auxiliary on-board propulsion system in October, 1984. The other ERBE instruments are being flown on NOAA-F and NOAA-G; NOAA-F was launched in December 1984, and NOAA-G is planned for launch in early 1986.

The FY 1986 funding is required to support the operation of ERBS and analysis of the data collected by experiments on ERBS, NOAA-F and NOAA-G. Additional FY 1986 and subsequent funding for ERBE mission operations and data analysis will be provided through the Environmental Observations Extended Mission Operations budget.

BASIS OF FY 1987 FUNDING REQUIREMENT

EXTENDED MISSION OPERATIONS (ENVIRONMENTAL OBSERVATIONS)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Operations for the extended mission of:				
Nimbus 7	6,200	6,600	6,200	5,000
Solar mesosphere explorer (SME)	1,000	2,300	2,000	900
Correlative measurement/solar backscatter ultraviolet instrument	2,300	1,400	2,200	3,900
Earth radiation budget experiment extended operations	1,500	7,100	7,200	8,900
Active magnetospheric particle tracer explorer extended operations	2,000	3,800	3,600	3,000
International sun-earth explorers	6,700	6,600	6,600	4,600
Interplanetary monitoring platform	800	600	700	700
Dynamics explorer extended operations	9,000	8,500	8,500	6,600
San marco extended operations	---	100	---	---
Total	29,500	37,000	37,000	33,600

OBJECTIVES AND STATUS

The objectives of the extended mission operations is to provide for the operations, data processing, validation and data analysis of missions which have completed basic operations funded by approved project support.

Launched in 1978, the Nimbus-7 spacecraft continues to provide significant quantities of both atmosphere and solid earth global data for multi-discipline investigations and applications. These include atmospheric dynamics and chemistry resulting in global ozone measurements that are helping to understand the complicated heat exchanges of the atmosphere-ocean system, and, for the first time, global ocean data and sea ice concentration as well as properties of both polar caps. NASA supplies this unique sea ice concentration data in near real-time to the joint U.S. Navy-NOAA Ice Center. The ocean color measurements provide the only data on open ocean and coastal areas chlorophyll concentration, which relates to abundance of phytoplankton, the basic element of the ocean food chain. Current studies of complete ocean basins are expanding the understanding of global productivity. Nimbus-7 operations and data reduction/validation activities will continue in FY 1987 to support the stong demand for data.

The Solar Mesosphere Explorer (SME), launched in October 1981, is providing major input to our overall atmospheric parameter data base. SME is producing simultaneous measurements needed to understand the complex chemical processes taking place in the mesosphere, including data measurements of ozone, atomic oxygen, nitric oxide and temperature. Data results indicate greater short-term variations and magnitude than was expected of many of the mesospheric properties. A ground truth program to aid in the validation of the SME data is also being undertaken. SME is providing excellent data on the effect of volcanoes on the Earth's atmosphere.

Solar terrestrial research activities rely on data received from the International Sun-Earth Explorers, the Interplanetary Monitoring Platform (IMP), and the Dynamics Explorers which are still operational. Recent analysis of DE-1 data have shown coupling of plasma and mesospheric chemistry. IMP continues to provide the only available source of solar wind input measurements to the Earth. The combined measurements of ISEE-1 and -2 in the same eccentric orbit continue to provide important data to study the structure and motions of the essential magnetospheric boundaries, bow shock, magnetopause, plasma pause and sheet. ISEE-3 made important first time measurements of solar wind-magnetosphere interraction in the Earth's distant geotail. The ISEE-3 spacecraft, renamed the International Cometary Explorer (ICE), accomplished a successful encounter with Comet Giacobini-Zinner in 1985. ICE will also provide complementary solar wind measurements upstream of Comet Halley in late 1985 and early 1986.

CHANGES FROM 1986 BUDGET ESTIMATE

The FY 1986 current estimate remains unchanged from the budget estimate in total, however adjustments have been made within the extended operations program to better align the funding with the actual operating spacecraft requirements and to apply $.5 million to modifications on the Galileo replacement aircraft.

BASIS OF FY 1987 ESTIMATE

FY 1987 funding is required to support continuing mission operations and data analysis activities for the International Sun-Earth Explorers, the Interplanetary Monitoring Platform and the Dynamics Explorers. Extended operations support of the Active Magnetospheric Particle Tracer Explorer, which was launched in 1984, will be continued in FY 1987. Operation of the Nimbus and SME satellites and processing of the collected data will be continued as will activities to provide ground truth for a NASA-developed ozone instrument to be flown on a NOAA meterological satellite. The SME and Nimbus satellites continue to produce extremely valuable data on ozone concentrations which will be used to estimate the occurrence of natural and man-made variations, sea surface temperatures, aerosol measurements, and ocean productivity. Correlative ground truth activities will also be continued in FY 1987; these in situ observations are needed to verify the quality of remote observations and improve our ability to interpret them.

In addition, FY 1987 funding is required for the operating ERBE instruments, payloads, and data set processing and analysis that will occur as the third set of instruments is launched on NOAA-G.

BASIS OF FY 1987 FUNDING REQUIREMENT

INTERDISCIPLINARY RESEARCH

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Interdisciplinary research and analysis	1,000	1,000	1,000	1,100

OBJECTIVES AND STATUS

Interdisciplinary research activities need to be conducted to quantitatively characterize the Earth's chemical, physical, and biological processes on the land, along with the interactions between the land, the oceans, and atmosphere, which are of particular importance in assessing the impact of these phenomena on global, physical, and biogeochemical processes. Such research is essential to investigating and assessing long-term physical, chemical, and biological trends and changes in the Earth's environment. Included in the program activities are joint efforts from a variety of disciplines, including atmospheric science, climatology, biological sciences, geochemistry, and oceanography.

BASIS OF FY 1987 ESTIMATE

In FY 1987, interdisciplinary studies will be continued with emphasis on integrating discipline-specific research activities of Oceanic Processes, Atmospheric Dynamics and Radiation, Upper Atmosphere/Troposphere Chemistry, and Land Processes into a unified program which will help increase our understanding of critical global processes. Emphasis will be placed on specific pilot studies such as those understanding the biogeochemical processes controlling the concentration of atmospheric methane, characterizing changes in properties of the land surface and their effect on climate, and understanding the role of the oceans in the global carbon cycle.

BASIS OF FY 1987 FUNDING REQUIREMENT

TETHERED SATELLITE PAYLOADS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Tethered satellite payloads...........	3,000	4,500	4,500	1,000

OBJECTIVES AND STATUS

The Tethered Satellite System (TSS) will provide a facility for conducting experiments weighing 500 kg or less from distances of 100 km above or below the Space Shuttle. The TSS will allow unique science to be undertaken such as observations of atmospheric processes occurring within the lower thermosphere (below 180 km altitude), observations of crustal geomagnetic phenomena, and direct observation of magnetospheric-ionospheric-atmospheric coupling processes in the 125-180 kilometer region. In addition, the satellite, coupled to the conducting tether, can generate large amplitude hydromagnetic waves and electrodynamic waves in the local space plasma, thus enabling active space plasma and magnetospheric physics experiments to be performed. The objective of the initial TSS mission is to verify the controlled deployment, retrieval and on-station stabilization of the satellite tethered from the orbiter, and to carry out scientific research using a conducting tether extended 20 km above the orbiter. NASA is providing the scientific payloads for the initial flight of the TSS.

The TSS is an international cooperative project with the Italian government. The United States is developing the tether deployment and retrieval system, is responsible for overall project management and system integration, for development and integration of the instruments, and flight on the Shuttle. Italy is developing the satellite and is responsible for development and integration of European investigations. An Announcement of Opportunity for investigations was issued in April 1984. Selection of investigators was completed in late 1985 and instrument design will be initiated in early 1986.

Some program delays are currently being encountered by the Italians in the development of the satellite, and the launch schedule is being reevaluated.

BASIS OF FY 1987 ESTIMATE

The FY 1987 funding is required for final preparations and data analysis activities associated with the scientific instruments on the Tethered Satellite System.

BASIS OF FY 1987 FUNDING REQUIREMENT

SCATTEROMETER

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Scatterometer.........................	12,000	31,700	14,000	35,900

OBJECTIVES AND STATUS

The purpose of the Navy Remote Ocean Sensing System (N-ROSS) is to acquire global ocean data for operational and research usage by both the military and civil sectors. A Scatterometer sensor is required to meet the objectives of this mission. NASA will provide the Scatterometer sensor and the Department of Defense will provide the N-ROSS spacecraft and launch services for a launch in late 1990.

The Scatterometer will provide accurate, global measurements of ocean surface winds which will be useful for both oceanography and meteorology. In addition to satisfying Navy operational requirements for providing wind field data, Scatterometer data will permit the first global study of the influence of winds on ocean circulation, provide data on the effects of the oceans on the atmosphere, and provide improved marine forecasting (winds and waves). Flight of the N-ROSS in late-1990 will provide an overlap of data gathering with the World Ocean Circulation Experiment and Tropical Ocean-Global Atmospheres Experiment planned by the international oceanographic community.

The feasibility of using the Scatterometer technique from space to accurately measure winds was demonstrated by Seasat in 1978. Definition studies conducted by NASA during FY 1983 and early FY 1984 resulted in the determination that the performance requirements as stated jointly by the research community and the Navy could be satisfied by utilizing system design concepts similar to those used on the Seasat Scatterometer. The major improvements include the addition of two antennas for improved wind direction determination and the addition of digital filtering to compensate for earth rotational effects. In FY 1985, the design and development activities were initiated, not only on the Scatterometer instrument, but also on the ground data processor which will utilize research quality algorithms to process the scatterometer raw data into geophysical products for utilization by the oceanographic and meteorological research communities. An Announcement of Opportunity (AO) for specific research investigations using Scatterometer data was released in FY 1985. Contracts were awarded for the antennas and travelling wave tubes. In FY 1986, a Preliminary Design Review will be conducted and the AO selection process will be completed.

CHANGES FROM 1986 BUDGET ESTIMATE

The $17.7 million decrease is consistent with Congressional direction. This has resulted in a six month delay in the instrument delivery to the Navy without any immediate impact to the Navy N-ROSS launch date.

BASIS OF FY 1987 ESTIMATE

In FY 1987, design and development of the Scatterometer will be continued leading to the scheduled launch in late 1990. In particular, the antenna and travelling wave tube fabrication will be continued, fabrication of the radio frequency subsystem will be initiated, procurement of a ground based computer system will be undertaken, and a critical design review will be completed.

BASIS OF FY 1987 FUNDING REQUIREMENT

UPPER ATMOSPHERE RESEARCH SATELLITE PROGRAM

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Spacecraft............................	21,700	80,200	67,200	99,500
Experiments..........................	34,000	53,800	56,800	52,700
Total..............................	55,700	134,000	124,000	152,200
Space Transportation System Operations	(---)	(---)	(---)	(18,400)

OBJECTIVES AND STATUS

The Upper Atmosphere Research Satellite (UARS) program is the next logical step in conducting a comprehensive program of research, technology development and monitoring of the upper atmosphere aimed at improving basic scientific understanding. This mission is essential for understanding the key radiative, chemical and dynamical processes which couple together to control the composition and structure of the stratosphere. The UARS mission will provide the first integrated global measurements of: ozone concentration; chemical species that affect ozone; energy inputs; temperature; and winds in the stratosphere and mesosphere. These measurements will complement the measurements of ozone and of atmospheric parameters affecting ozone that were made on Nimbus and SAGE. The UARS program is a critical element in overall stratospheric research and monitoring efforts; it will provide the first full data set on stratospheric composition and dynamics which will be required when very difficult decisions must be made in the future regarding production of chlorofluorocarbons. The UARS mission will also contribute to the assessment of the impact of stratospheric changes on our climate and will provide the data needed for a full understanding of the stratosphere. These understandings are essential for subsequent design and implementation of a long-term stratospheric monitoring activity.

A final selection of ten experiments has been made, including infrared and microwave limb sounders which require advances in cryogenics, solid-state devices and microwave antennas beyond earlier capabilities. The instrument design and development activities are underway. A Solar Backscatter Ultraviolet (SBUV) instrument will be modified to fly on the Shuttle during the UARS mission and to provide correlative data. In addition, development of the central ground data handling facility, which will permit near-realtime interactive utilization of data by the twenty-one design and theoretical investigator teams, is underway.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The total $10.0 million decrease is consistent with Congressional direction.

BASIS OF FY 1987 ESTIMATE

The FY 1987 funds are requried for continuation of the development activities on the ten UARS instruments including flight hardware fabrication, instrument assembly and environmental testing leading to instrument delivery to the spacecraft in 1988. In addition, the spacecraft design and development activities will be continued in FY 1987 leading to the observatory critical design review in the latter half of FY 1987 and the initiation of flight hardware fabrication.

The ground data handling facility will enable a higher level of interaction among experimenters and theoreticians than has existed with past programs. Implementation of this concept requires that the system be developed on a timely parallel path with the flight hardware so that individual experiment data processing subsystems, including algorithms and the interactive data base, provide maximum interaction and effectiveness in the design and development phase of the program and are fully verified at launch time. In order to achieve this, FY 1987 funding is required to continue design and development of the ground data handling facility including: hardware delivery and checkout, software preliminary and critical design reviews, science team support and science algorithm development.

BASIS OF FY 1987 FUNDING REQUIREMENT

OCEAN TOPOGRAPHY EXPERIMENT

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Ocean topography experiment (TOPEX)...	---	---	---	29,000

OBJECTIVES AND STATUS

The goal of the Ocean Topography Experiment (TOPEX) is to utilize satellite radar altimetry to measure the surface topography of the global oceans over a period of three years with sufficient accuracy and precision to significantly enhance our understanding of the oceans' general circulation and its mesoscale variability. The capability of satellite altimetry to address this goal was demonstrated in 1978 by NASA's highly successful Seasat program. Such information is needed to better understand how the atmosphere drives the circulation of the oceans, how the oceans in turn influence the atmosphere and ultimately, the role of the oceans in climate.

Current plans call for NASA and the French Space Agency (CNES) to collaborate on TOPEX in order to more fully exploit the scientific value of the data. In exchange for this scientific collaboration and the flight of a French altimeter and tracking system, CNES will launch TOPEX in mid-1991 using Ariane. TOPEX is also being planned in concert with the World Ocean Circulation Experiment (WOCE), a major international oceanographic field program being planned under the auspices of the World Climate Research Program (WCRP). WOCE will combine satellite observations from TOPEX with traditional in situ observations to enable the first comprehensive determination of the three-dimensional current structure of the global oceans. When further combined with ocean surface winds from the NASA Scatterometer (NSCAT) planned for flight on the U.S. Navy Remote Ocean Sensing System (N-ROSS) in late 1990, unique measurements of the oceans' driving force (winds) and the resulting ocean response (topography) will have been obtained.

BASIS OF FY 1987 ESTIMATE

During FY 1986, a Request for Proposals (RFP) to select a single satellite contractor and an Announcement of Opportunity to select a Science Working Team are planned to be issued. Once these selections have been made, NASA will be in a position to initiate full scale development of TOPEX, thus permitting a May 1991 launch. The resulting high degree of overlap with N-ROSS and WOCE will permit a truly unique set of coordinated spaceborne and in situ observations to be obtained.

In FY 1987 detailed design work in all areas of the project--satellite, sensors, ground data system, etc.--will be focused on preparing for a Critical Design Review (CDR) in early FY 1988 such that hardware fabrication can be initiated.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS **MATERIALS PROCESSING IN SPACE PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
	(Thousands of Dollars)				
Research and analysis.................	11,700	12,400	12,400	12,900	RD 8-3
Materials experiment operations.......	15,300	21,600	22,600	31,000	RD 8-4
Total..............................	27,000	34,000	35,000	43,900	

Distribution of Program Amount by Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Johnson Space Center..................	2,661	3,150	3,900	3,700
Marshall Space Flight Center..........	8,353	10,980	8,000	12,300
Lewis Research Center.................	5,767	6,700	6,600	6,700
Langley Research Center...............	1,256	1,200	1,300	2,300
Jet Propulsion Laboratory.............	4,544	8,075	6,600	9,700
Headquarters..........................	4,419	3,895	8,600	9,200
Total..............................	27,000	34,000	35,000	43,900

PROGRAM OBJECTIVES AND JUSTIFICATION

The Materials Processing in Space program emphasizes the science and technology of processing materials to understand constraints imposed by gravitational forces and the unique capabilities made possible by controlling these processes in the space environment. Ground-based research, technology development, and payload definition activities in FY 1986 are being concentrated on six major processing areas: metals and alloys, electronic materials, glass and ceramics, biotechnology, combustion, and fluid dynamics and transport phenomena. These activities will provide the scientific basis for future space applications of materials processing technology as well as provide a better understanding of how these processes occur on the ground. Definition studies will be performed for Shuttle experiment candidates in areas such as containerless experiments, combustion science, solidification and crystal growth, and blood storage. Also included are maintenance of capabilities for experimentation in drop tubes, towers, and aircraft. Studies and science support for Joint Endeavor and Technical Exchange Agreements are included in this program.

Materials Experiment Operations is a consolidation of ongoing activities which provide a range of experimental capabilities for all scientific and commercial participants in the Microgravity Science and Applications program. These include Shuttle mid-deck experiments, the Materials Experiment Assembly and the Materials Science Laboratory, which is carried in the orbiter bay. These capabilities will enable users to develop different experiments in a cost-effective manner and allow a better understanding of the technical risks associated with experiment concepts before attempting to develop more complex hardware. In addition, reflight of investigations on Shuttle/Spacelab missions and the mid-deck is provided for in Materials Experiment Operations.

BASIS OF FY 1987 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS (MATERIALS PROCESSING)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Ground-based investigations, analysis and studies................	11,700	12,400	12,400	12,900

OBJECTIVES AND STATUS

The research and analysis activity provides the scientific foundation for all current and future projects in the Microgravity Science and Applications program. Emphasis is placed on ground-based research which is expected to evolve into space investigations with potential for future applications. This activity also supports technology development for future ground and space capabilities, and commercialization activities leading toward privately-funded space enterprises. Most research projects are initiated as a result of proposals from the scientific community which have been extensively reviewed by peer groups prior to selection. The FY 1986 funding is being used to support ongoing research in infrared detector materials, spherical shell technology, floating zone crystal growth, separation and synthesis of biological materials, fluid flow effects in materials processing, combustion science, and containerless processing techniques. Coordinated activities with the NASA Office of Commercial Programs will continue with studies of institutional arrangements associated with joint NASA/industry ventures, information activities directed toward industry involvement in microgravity science and applications projects, and early negotiations and continuing technical support with companies interested in undertaking joint space endeavors with NASA.

BASIS OF FY 1987 ESTIMATE

Ground-based research and analysis will be continued in FY 1987 in the areas of metals and alloys, electronic materials, glass and ceramics, biotechnology, combustion, and fluid dynamics and transport phenomena. Research will be conducted to define the role of gravity-driven influences in generic processing methods. Effort will continue at the centers for bioprocessing research located at the University of Arizona and the University City Science Center in Philadelphia, PA as well as the Microgravity Materials Science Lab at the Lewis Research Center.

BASIS OF FY 1987 FUNDING REQUIREMENT

MATERIALS EXPERIMENT OPERATIONS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Materials experiment operations.......	15,300	21,600	22,600	31,000

OBJECTIVES AND STATUS

The materials experiment operations program provides a wide range of opportunities for scientific and commercial experiments in microgravity science and applications. Development of Shuttle mid-deck and cargo bay experiments are supported under this activity. Preliminary data analysis on Shuttle experiments already flown has shown promising results.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The funding increase of $1.0M will be used to augment the materials processing flight experiment activities, and to initiate the study of advanced experiment apparatus for research in glasses and ceramics.

BASIS OF FY 1987 ESTIMATE

FY 1987 funding is required to continue basic and applied research activities using mid-deck and cargo bay experiments leading to several flights over the next few years. Investigations will be conducted in glasses, electronic materials, biotechnology, metals and alloys, and combustion. Development will begin on a number of Physics and Chemistry Experiments (PACE) as well as continued development of several pieces of advanced equipment in the areas of electronic crystal growth, biotechnology, metallic casting, and particle combustion.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS **COMMUNICATIONS PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Advanced Communications Technology Satellite (ACTS)....................	45,000	90,000	85,000*	---	---
Research and analysis.................	9,100	10,600	10,400	14,000	RD 9-4
Search and rescue.....................	2,400	1,300	1,300	1,000	RD 9-6
Technical consultation and support studies.....................	2,900	3,100	2,600	3,200	RD 9-7
Experiment coordination and operations support............................	1,200	1,200	1,000	1,300	RD 9-9
Total..............................	60,600	106,200	100,300	19,500	

Distribution of Program Amount by Installation	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Goddard Space Flight Center...........	3,792	2,720	4,220	5,087
Jet Propulsion Laboratory.............	4,579	6,000	5,416	8,272
Ames Research Center..................	---	---	---	---
National Space Technology Laboratories	---	---	---	---
Langley Research Center...............	---	---	---	---
Lewis Research Center.................	48,955	94,200	87,535	5,100
Headquarters..........................	3,274	3,280	3,129	1,041
Total..............................	60,600	106,200	100,300	19,500

*A proposed recission of $26,796 for this project is included in the President's Budget.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

OFFICE OF SPACE SCIENCE AND APPLICATIONS — **COMMUNICATIONS PROGRAM**

OBJECTIVES AND STATUS

The Communications Research and Analysis program continues to provide development of component and device technology required by NASA, other government agencies, and U.S. industry for advanced communications satellite systems. Special emphasis is being given to pursuing technologies with high potential for improving spectrum utilization, satellite switching, and intersatellite link technologies, since these technologies are the key to future growth of the communication satellite and terminal markets. In addition, the mobile communications technology program will continue to address the development of critical enabling technologies needed to insure growth of a commercial mobile satellite service in the U.S. This effort, in cooperation with U.S. industry, Canada, and other government agencies, will help implement a first generation commercial system at the end of the decade.

The Search and Rescue program is an international cooperative program that demonstrates the use of satellite technology to detect and locate aircraft or vessels in distress. The United States, Canada, France, and the Soviet Union developed the system, in which Norway, the United Kingdom, and Sweden also participate. A four satellite system is now in service (two U.S. and two U.S.S.R. satellites) and has been credited with saving over 500 lives in numerous worldwide incidents. The list continues to grow weekly. The resources requested reflect the fact that the primary responsiblity for this program has been transferred to NOAA.

The technical consultation and support program will continue to provide for studies of radio interference, propagation and special systems required for the growth of existing satellite services and the extension of new satellite applications. Support to the Department of State, the Federal Communications Commission, the National Telecommunications and Information Administration, and other Agencies in the development of frequency and orbit sharing techniques and strategies for upcoming World Administrative Radio Conferences (WARC's) is continuing.

The experiment coordination and operations support program assists other federal agencies and public sector organizations in the development of experimental satellite communications for emergency, disaster and public service applications. Operation of the Applications Technology Satellite (ATS) 3 is continuing through contracts with the University of Miami.

Development work will be terminated on the Advanced Communications Technology Satellite demonstration flight. A proposed recission has been included in the President's Budget for this project.

BASIS OF FY 1987 FUNDING REQUIREMENT

RESEARCH AND ANALYSIS (COMMUNICATIONS)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Research and analysis.................	9,100	10,600	10,400	14,000

OBJECTIVES AND STATUS

The Communications Research and Analysis program emphasizes the development of high-risk technology required to maintain U.S. preeminence in the international satellite communications market, to enable new and innovative public services, and to meet the communications needs of NASA and of other government agencies. This program focuses on the "interconnectivity technologies" of on-board switching, intersatellite links, and antennas, as well as the conventional RF technologies. Advanced studies are performed to determine the future satellite communications needs of the country, and to define the technology required to meet those needs. The technology is developed and tested through an advanced proof-of-concept (POC) program. The POC devices and components are then integrated into a multiple terminal, satellite communications network in a laboratory where they undergo comprehensive evaluation.

In 1986, work is continuing on intersatellite laser link technology. This advanced technology has the potential to significantly improve intersatellite communications by allowing high data rate transmission in the Space Station era. Technology development is also underway in the area of monolithic microwave integrated circuits (MMIC), which have significant potential for applications in multiport spacecraft matrix switches, low noise receivers, and multibeam antenna arrays and beam-forming networks. A number of industry studies are being sponsored to assess new areas of communications technologies required for the 1990's.

The mobile communications technologies activity is aimed at accelerating the introduction of a commercial mobile satellite service in the U.S., and developing power, bandwidth and orbital-slot efficient ground segment technology and networking techniques needed to insure its growth. An innovative cooperative agreement between NASA and industry was signed in FY 1985 as the basis for this effort. In early FY 1986, our technology development program received support of the industry at a major government/industry briefing. We are continuing to work with other government agencies to define an experimental test program aimed at emergency response and public service applications.

In FY 1986, development efforts on ground segment technology is continuing. Definition of low cost, high gain rooftop vehicle antennas that can at least double the number of orbital slots available has been completed and development of engineering hardware models is underway. Design is continuing on terminal and networking techniques that will result in power/bandwidth efficient voice transmissions (approximately six times greater than the new cellular terrestrial technology) and information (voice plus data) throughput increases. NASA will continue to work with the private sector and other government agencies to define a field test planned for late 1986. To achieve this, and to foster cooperation during the experimental phase, seven Memoranda of Understanding have been signed. These represent almost 30 government agencies.

CHANGES FROM THE FY 1986 BUDGET ESTIMATE

The decrease in the FY 1986 budget estimate reflects FY 1986 agency operating plan adjustments to provide for other higher priority requirements.

BASIS OF FY 1987 ESTIMATE

During FY 1987, advanced studies and selected technology development will be continued in the focussed high risk areas of satellite switching, RF (radio frequency) systems, intersatellite links and mobile communications. Work in these technology areas will support U.S. industry, NASA, and other government agencies and address national economic and security interests.

FY 1987 mobile communications technology activity will focus on field tests of advanced concepts in an operational-like environment. These initial tests, which will involve NASA, other agencies, U.S. industry, and Canada, are a critical first step in tying together the advanced technology elements under development for a future mobile satellite communications experiment.

BASIS OF FY 1987 FUNDING REQUIREMENT

SEARCH AND RESCUE

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Search and rescue......................	2,400	1,300	1,300	1,000

OBJECTIVES AND STATUS

The Search and Rescue program, developed by NASA and its international partners, has demonstrated the feasibility of using satellites to significantly improve the ability to detect and locate general aviation aircraft and marine vessels during emergencies. The Search and Rescue satellite systems has met all specifications and was declared operational in July 1985. The system has received world-wide acclaim and has been credited with saving over 500 lives to date. In addition, the system is demonstrating the potential to save millions of dollars annually in search logistics costs.

In FY 1986, work is continuing to improve system software efficiency, develop low-cost 406 MHz hardware, and initiate development techniques that will enhance the ability of the system to quickly locate those in distress.

BASIS OF FY 1987 ESTIMATE

In FY 1987, an experiment will be undertaken to evaluate the use of geostationary satellites for instant alerting of search and rescue forces. Work will also continue on the development and tests of other technologies with the potential to further enhance capabilities for effective search and rescue.

BASIS OF FY 1987 FUNDING REQUIREMENT

TECHNICAL CONSULTATION AND SUPPORT STUDIES

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Technical consultation and support studies.....................	2,900	3,100	2,600	3,200

OBJECTIVES AND STATUS

Technical consultation and support studies provide the technical basis for regulatory and policy development to assure the orderly growth of existing and new satellite services. Unique analytical tools are developed and used to solve problems of inter- and intra-satellite/terrestrial system interference. Emphasis is placed on orbit and spectrum utilization studies, which include the development of frequency and orbit sharing techniques and strategies, design standards, and the determination of the effect of propagation phenomena and man-made noise on performance, design, and efficient use of the geostationary satellite orbit and the radio spectrum.

NASA studies and participation in the Space World Administrative Radio Conference (SWARC) in the summer of 1985 contributed to the successful outcome of the conference. Propagation measurements, carried out during FY 1985 and FY 1986 with balloons, drone aircraft, and helicopters, are providing new insight to industry on the effects of trees and foliage on mobile satellite communications. NASA continues to respond to and support the rulemaking by the Federal Communications Commission (FCC) to establish a commercial land mobile satellite service. The rulemaking, anticipated for early 1986, is expected to result in a new multibillion dollar industry with both domestic and foreign markets and a commercial service owned and operated by the private sector by the late 1980's.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease in the FY 1986 budget estimate reflects FY 1986 agency operating plan adjustments to provide for other higher priority requirements.

BASIS OF FY 1987 ESTIMATE

During FY 1987, studies and analyses will be performed to support preparations for the second session of the SWARC which is scheduled to be held in Geneva in 1988. Plans will be developed for the fixed-satellite service at that time and proper preparation is critical to U.S. objectives for maintaining flexibility in orbiting and operating communications satellites. NASA will complete preparations for and will participate in the 1987 WARC on mobile communiations services. Studies will continue for the purposes of identifying techniques to increase the efficient use of the limited orbit/spectrum resources and to understand and alleviate the adverse effcts of propagation phenomena on space communications.

BASIS OF FY 1987 FUNDING REQUIREMENT

EXPERIMENT COORDINATION AND OPERATIONS SUPPORT

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Experiment coordination and operations support.............................	1,200	1,200	1,000	1,300

OBJECTIVES AND STATUS

The objective of this program is to support and document a wide range of user experiments and demonstrations in the application of satellite communications. Past experiments on experimental satellites such as the Applications Technology Satellite (ATS) series and the Communications Technology Satellite (CTS), have been successfully providing users with the experience necessary for making informed decisions regarding their communications functions. NASA's stimulus in encouraging use of these unique facilities has led to wider application of commercial satellites, which can better meet the needs of potential users.

ATS-1, a 19-year old experimental satellite that provided humanitarian telecommunications service to 23 Pacific island nations for the past 14 years was shut down when it would no longer respond to station-keeping commands. NASA is currently assessing replacement options. The remaining ATS satellite, ATS-3, will continue to provide two-way voice and data transmission for a number of experiments being conducted in North America, the Antarctic, and the Pacific and Atlantic oceans, in support of the National Science Foundation, the Department of the Navy, the Department of Commerce, a number of universities, and private industry. It continues to be an important link for emergency communications in the western hemisphere as was demonstrated during the recent Mexico City earthquake and Columbia volcanic eruption.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease in the FY 1986 budget estimate reflects FY 1986 agency operating plan adjustments to provide for other higher priority requirements.

BASIS OF FY 1987 ESTIMATE

In FY 1987, operational support for ATS-3 will continue; NASA will maintain approval and policy control of the ATS program. NASA will continue planning support for educational, scientific, and public service communications experiments for organizations within the western hemisphere, and will support similar experimental activities of Pacific basin organizations within the footprint of the ATS-3 coverage. Efforts in support of a replacement system for ATS-1 will continue with low-cost, prototype ground terminal development, analyses of viable alternative satellite systems, and verifiction systems tests.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE SCIENCE AND APPLICATIONS **INFORMATION SYSTEMS PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Data systems	8,400	9,000	9,000	9,300	RD 10-2
Information systems	7,800	10,200	9,700	11,900	RD 10-2
Total	16,200	19,200	18,700	21,200	
Distribution of Program Amount by Installation					
Johnson Space Center	—	210	---	---	
Marshall Space Flight Center	125	130	---	---	
Goddard Space Flight Center	9,602	12,050	12,680	14,880	
Jet Propulsion Laboratory	5,034	5,050	4,609	4,909	
Ames Research Center	270	350	---	---	
National Space Technology Laboratories	240	210	190	200	
Headquarters	929	1,200	1,221	1,211	
Total	16,200	19,200	18,700	21,200	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

OFFICE OF SPACE SCIENCE AND APPLICATIONS **INFORMATION SYSTEMS PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATION

The objectives of the Information Systems program are to: develop and demonstrate advanced capabilities of managing, distributing, and processing data and information; implement information system standards and provide common software in order to lower data system costs; and develop the basis for data services to provide improved access to, and rapid delivery of, space data and advanced data systems in support of the Nation's satellite programs and space science and applications projects.

This program provides for timely development of data system capabilities to meet the needs of flight missions and major space science and applications programs. The early demonstration of capabilities has a high potential for reducing ground data system development risks and for providing timely delivery of data to researchers.

CHANGES FROM FY 1986 BUDGET ESTIMATES

The decrease of $.5 million in FY 1986 reflects agency operating plan adjustments previously identified to Congress. The reduction will be accomplished by curtailing "grave yard shift" activities at the Space and Earth Science Computing Center.

BASIS OF FY 1987 ESTIMATE

The FY 1987 Information Systems funding is required to provide support for space science and applications programs. Funds are required to continue development of planetary, earth resources, and astrophysics data systems projects which are being implemented at the Jet Propulsion Laboratory, the Goddard Space Flight Center, and participating academic institutions; to continue implementation of on-line data directories and catalogs; to operate the large-scale computers in the Space and Earth Sciences Computing Center (SESCC) and the archives at the National Space Science Data Center (NSSDC) both facilities located at the Goddard Space Flight Center; to develop common software to support ongoing research in the space and earth sciences; and to continue development of data management and data archiving to support flight projects, discipline program offices, and other NASA program offices. The FY 1987 funding levels will also provide the university/research community with improved access to NASA computational facilities and data archives by expanding network communications links, by increasing online data storage capacities, and by developing standards for data and protocols.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FFISCAL YEAR 1987 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR COMMERCIAL PROGRAMS

Commercial Programs	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Technology utilization.........................	9,500	11,100	11,100	13,300
Commercial use of space........................	(7,600)	30,000	17,000	32,000
Total....................................	9,500	41,100	28,100	45,300

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 BUDGET ESTIMATES

BUDGET SUMMARY

OFFICE OF COMMERCIAL PROGRAMS | **TECHNOLOGY UTILIZATION PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

		1986		1987	
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate	Page Number
		(Thousands of Dollars)			
Technology dissemination..............	5,800	6,300	6,300	7,600	RD 11-4
Technology applications...............	3,700	4,800	4,800	5,700	RD 11-5
Total.......................	9,500	11,100	11,100	13,300	

Distribution of Program Amount by Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Johnson Space Center..................	202	250	175	300
Kennedy Space Center..................	335	210	490	415
Marshall Space Flight Center..........	184	390	268	530
National Space Tech Laboratories......	185	100	300	210
Goddard Space Flight Center...........	1,132	1,050	1,295	1,259
Jet Propulsion Laboratory.............	135	510	680	345
Ames Research Center..................	106	2,010	155	400
Langley Research Center...............	697	530	408	573
Lewis Research Center.................	412	310	443	1,007
Headquarters..........................	6,112	5,740	6,886	8,261
Total.............................	9,500	11,100	11,100	13,300

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 BUDGET ESTIMATES

OFFICE OF COMMERCIAL PROGRAMS **TECHNOLOGY UTILIZATION PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATION

The objective of the NASA Technology Utilization Program is to enhance the national economy and industrial productivity through a series of interactive processes and mechanisms designed to transfer aerospace technology evolving from NASA's R&D programs to non-aerospace sectors of the U.S. economy. Almost every part of U.S. industry is touched by the transfer process, especially in such areas as automation, electronics, materials, and productivity. In the public sector, medicine, rehabilitation, transportation, and safety are but a few of the areas receiving benefits. The specific objectives of the program are:

- Accelerate application and use of aeronautics and space technology by the U.S. private sector;
- Facilitate multiple secondary uses and application of NASA technology by the public and private sectors and academia;
- Continue to improve NASA's technology transfer process;
- Promote applications of NASA's expertise and capabilities to non-aerospace needs of the Nation.

OBJECTIVES AND STATUS

NASA Tech Briefs is the Agency's principal technology announcement publication designed to promote and encourage the effective secondary use of new aerospace advancements. Conversion of *NASA Tech Briefs* to a commercially viable, private sector publication was accomplished on schedule with the first commercial issue released in February 1985. A subsequent agreement was reached with the private sector publisher and the Joint Committee on Printing in December 1985 for continuation of a commercial version of the *NASA Tech Briefs* journal for the next five years. This commercialization effort (a) allows the continued free distribution of this quarterly journal to current subscribers (100,000 scientists, engineers and business representatives in U.S. industry), and (b) provides for circulation growth to meet the demand throughout industry, which is estimated at two to three times the present readership.

Thousands of U.S. industrial firms are being provided computerized access to NASA information through the NASA-sponsored dissemination center network. Technology transfer services growing out of this information access have focused a wide array of technologies on technological problems specified by industrial clients. These firms, especially those in the industrial manufacturing and research sectors, have found dissemination center information and technology transfer services to be beneficial in the development of new or improved products or processes. COSMIC, the NASA-supported center for computerized software dissemination, realized significant growth in sales and lease of NASA-developed computer programs for industrial use. Overall, the entire predominantly university-based dissemination network received approximately $7 million from industry last year for information products and technology transfer services, underscoring the continued interest and importance which this activity has throughout industry.

In applications engineering, emphasis during 1986 continues to be concentrated on developing new oportunities in automation, electronics and materials technology, and solidifying ongoing projects and studies in the allied medical fields (bioengineering and rehabilitation). The development of the Programmable Implantable Medication System was accelerated as Siemens Industries purchased Pacesetter, Inc. and the FDA approved human trials for morphine and insulin. During the same period INTEC, the manufacturer of the implantable defibrillator, was purchased by Cardiac Pacers, Inc. (CPI). The FDA has given CPI the authority to commercialize this life saving device. CPI is committed to accelerate the marketing of the device and development of the next generation of defibrillators. There are over 800 of these devices currently implanted in humans. In the automation, electronics and materials area, three new projects in materials technology were started at the Lewis Research Center. Each project has a major manufacturer involved. Two feasibility studies in electronics and automation were successfully completed and the next phase of engineering development intiated. Additionally, a materials project designed to measure residual stress in steel components without having a calibration standard was transferred to the U.S. industry. The National Space Technology Laboratories aquaculture treatment techniques to convert raw sewage to drinking water is all but complete as a pilot project with Federal and state support in the city of San Diego, California. The Library of Congress and NASA jointly agreed on preliminary specifications for a book deacidification facility at Fort Detrick, Maryland.

BASIS FOR FY 1987 ESTIMATE

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Technology dissemination.............	5,800	6,300	6,300	7,600

OBJECTIVES AND STATUS

In FY 1987, NASA will continue to enhance, restructure, and refine NASA technology dissemination systems capabilities and techniques to heighten relevance and potential applicability of available technologies for industrial user needs, and provide technical information and technology transfer services to expanded user markets in the U.S. Technology dissemination efforts will be coupled with activities, where possible, of state-supported economic and industrial development programs to serve broader industrial markets nationwide, with particular emphasis on small and medium size manufacturing and high technology business firms. Enhancements in the NASA dissemination systems will continue by expanding the use of remote interactive and high speed data base search methods. Moreover, selected computer interface improvements will be explored. Increased use of telecommunications will also be pursued to provide rapid and effective delivery of technologies to meet the critical needs of U.S. industrial firms engaged in a wide range of scientific, engineering, manufacturing, and commercial pursuits. Industrial profile analyses will continue to be conducted. Market planning strategies will be pursued for emerging aerospace technologies, thus enhancing NASA's ability to accelerate the flow of research and development results to -- and their effective use in -- the U.S. industrial marketplace. Additionally, special emphasis will be placed on providing broader coordination and support to NASA's Industrial Application Center network through access to NASA laboratory expertise engaged in ongoing research and development activities that have a direct bearing on the nonaerospace industrial sector's technology needs. These coordination and support activities will include an expansion of the NASA Technology Counselor network as well as establishment of a Technology Transfer Institute. This effort will enhance the computerized systems interfaces with technology databases and heighten cost effectiveness and efficiency throughout the nationwide network.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Technology applications...............	3,700	4,800	4,800	5,700

OBJECTIVES AND STATUS

The Technology Applications Program is designed to respond to a national "pull" for technology that is needed by U.S. industry, state or federal government in order to meet the specific objectives of the user. Goals are defined in terms of enhancing the quality of life, increasing the marketability of U.S. industry and utilization of a national resource. This is accomplished by the transfer of new technology and information resulting from NASA R&D efforts to the non-aerospace segment of the economy. The main thrusts of the technology transfer effort will be in automation, electronics, materials, bioengineering and rehabilitation.

Additionally, in FY 1987, NASA will continue its efforts to reengineer, adapt, or otherwise apply existing aerospace technologies and capabilities to problem areas of national significance in both the public and private sectors of the economy. In the public sector, special emphasis will be placed on enhancing and expanding technology applications activities and projects to meet needs identified in biomedical and rehabilitation areas. This will be done in conjunction with user agencies such as the National Institutes of Health, the Veterans Administration, and other organizations concerned with the elderly, disabled and the handicapped. These areas of increased emphasis in FY 1987 will augment continuing technology applications program activities in other areas of public and human concern, such as public safety, transportation and the environment.

With regard to the private sector and its industrial entities, applications engineering activities will be pursued directly with them to determine their long range requirements and needs and determine how NASA's aeronautics and space technologies can be applied to solve recurring operational problems. Special emphasis will be directed to the involvement of applications projects essential to development of new products and processes to revitalize industries critical to the U.S. economy's research and development and manufacturing sectors, in addition to reshaping productivity capabilities of industries threatened by foreign competition. Important to this undertaking will be the development of proactive relationships with the U.S. private sector in all aspects of industrial activities.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF COMMERCIAL PROGRAMS

COMMERCIAL USE OF SPACE PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Commercial Applications R&D..........	(6,350)	28,500	15,500	30,100	RD 12-3
Commercial Development Support.......	(1,250)	1,500	1,500	1,900	RD 12-4
Total.............................	(7,600)	30,000	17,000	32,000	

Distribution of Program Amount by Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Johnson Space Center.................	(450)	1,600	600	1,600
Kennedy Space Center.................	(36)	1,500	200	1,500
Marshall Space Flight Center.........	(1,443)	6,200	4,000	6,200
National Space Technology Laboratories	(---)	400	200	400
Goddard Space Flight Center..........	(50)	800	450	800
Jet Propulsion Laboratory............	(---)	700	50	700
Ames Research Center.................	(130)	900	400	900
Langley Research Center..............	(300)	3,600	1,300	3,600
Lewis Research Center................	(750)	2,000	1,800	2,000
Headquarters.........................	(4,441)	12,300	8,000	14,300
Total.............................	(7,600)	30,000	17,000	32,000

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

OFFICE OF COMMERCIAL PROGRAMS **COMMERCIAL USE OF SPACE PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATION

The objective of the commercial use of space program is to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology, space-based research and development. Expansion of the level of private sector investment in commercial space activities will help the U.S. to retain its leadership in science and technology and accrue associated benefits to our nation. This program will be built on shuttle and related space-based operational capabilities. The program is responsive to the President's national space strategy and national policy on the commercial use of space, both of which direct NASA to expand private sector investment and involvement in space activities.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The commercial use of space program was reduced $13.0 million by Congressional direction. This reduction was made in commercial applications research and development and will be accomodated by reducing the rate of establishment of new Centers for the commercial development of space and development of supporting research equipment.

OBJECTIVES AND STATUS

The goal of the commercial use of space program is to provide a national focus in support of the expansion of U.S. private sector investment and involvement in civil space activities, while emphasizing new high technology commercial space ventures and promoting the development of new markets for the space transportation system (STS) and other NASA space services. The specific objectives of the program are to:

- Establish close working relations with the private sector and academia to encourage investment in space technology and the use of the *in situ* attributes of space - vacuum, microgravity and radiation - for commercial purposes.
- Facilitate private sector space activities through improved access to available NASA capabilities.

- Encourage an increase in private sector investment in the commercial use of space independent of NASA funding.

- Develop a national commercial space policy and provide for NASA-wide implementation.

FY 1986 activities include the implementation of the national policy on the commercial use of space, the maintainance of an organizational focal point for commercial programs at NASA, and the initiation of efforts specifically intended to foster commercial use of and access to space. These specific efforts include the establishment of additional centers for the commercial development of space (CCDS), increasing accessibility to NASA facilities and equipment, small focused research efforts on processes having commercial potential, and the incorporation of other functions designed to facilitate private sector utilization of space for commercial ventures.

BASIS FOR FY 1987 ESTIMATE

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Commercial Applications R&D...........	(6,350)	28,500	15,500	30,100

FY 1987 activities will provide a continuation and some enhancement of the FY 1986 program initiatives. These efforts are designed to encourage significant private investment in commercial enterprises that take advantage of the unique characteristics of space, such as hard vaccum and microgravity.

In FY 1987, the third round of CCDS selections will occur, which will complete the constellation of centers at around fifteen to eighteen. These consortia of industry, academia and non-NASA government participants are expected to effectively encourage the development of high technology space-related research having direct commercial interest and application. FY 1987 will also see a number of projects begun in FY 1985/86 move into final assembly stages or completion. In particular, the middeck galley rack will fly in FY 1987, carrying as its first payload the experiment of a U.S. company participating in commercially-oriented research through a NASA/industry joint endeavor agreement. In addition, the protein crystal growth system, building upon and expanding the capability of current rudimentary systems, will greatly increase the number and type of protein crystals which can be produced on a single STS mission. The production of these crystals in sufficient quality and size is a crucial step in drug design, enzyme engineering, molecular computing development, and biochip engineering.

Joint endeavor and other space act agreement activities are expected to substantially increase as the CCDS move forward in their research activities and as companies further define their research interests and programs. As of January 1986, NASA has executed 65 space act agreements with U.S. companies, of which 52 are research related (joint endeavor agreements, technical endeavor agreements, and industry guest investigators), nine are commercial hardware related, and two represent diverstitures of government programs (expendable launch vehicles).

Commercial Development Support........ (1,250) 1,500 1,500 1,900

These efforts will endeavor to increase the awareness of space as a potentially attractive environment for commercial development. Through studies, surveys and outreach efforts, U.S. industry particularly the non-aerospace sector, will be informed of and acquainted with the opportunities to work with NASA in space. FY 1987 will see the complete consolidation of all NASA user development activities. These efforts are associated with identifying and developing working partnerships with U.S. firms that will allow these firms to assess whether there are profitable product-related opportunities enabled through space-based R&D. An interactive network of all participants involved in user development will be in operation together with a reporting system which should minimize user costs and duplication while maximizing the effective application of existing NASA personnel and financial resources.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FFISCAL YEAR 1987 ESTIMATES

RESEARCH AND DEVELOPMENT BUDGET PLAN FOR AERONAUTICS AND SPACE TECHNOLOGY

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Aeronautical research and technology...........	342,400	354,000	354,000	376,000
Transatmospheric research and technology.......	---	---	---	45,000
Space research and technology..................	150,000	168,000	168,000	180,200
Total....................................	492,400	522,000	522,000	601,200

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY **AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

		1986		1987	
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and technology base...........	223,298	239,300	240,300	272,900	RD 13-6
Systems technology programs............	119,102	114,700	113,700	103,100	RD 13-38
Total...............................	342,400	354,000	354,000	376,000	
Distribution of Program Amount by Installation					
Johnson Space Center...................	1,055	1,000	1,100	1,100	
Marshall Space Flight Center...........	949	1,000	1,100	1,100	
Jet Propulsion Laboratory..............	188	200	200	200	
Goddard Space Flight Center............	290	300	300	300	
Ames Research Center...................	132,933	146,200	150,100	165,600	
Langley Research Center................	116,430	101,300	101,400	118,400	
Lewis Research Center..................	84,903	97,800	93,100	82,600	
Headquarters...........................	5,652	6,200	6,700	6,700	
Total...............................	342,400	354,000	354,000	376,000	

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY **AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM**

PROGRAM OBJECTIVES AND JUSTIFICATION

The objective of the aeronautical research and technology program is to conduct an effective and productive program that contributes materially to the enduring preeminence of U.S. civil and military aviation by: (1) conducting disciplinary and systems research at the leading edge of technology in those areas critical to the continued superiority of U.S. aircraft; (2) maintaining the research centers in positions of excellence in facilities and technical staff; (3) assuring timely transfer of research results to the U.S. aeronautical industry; (4) assuring appropriate involvement of universities and industry; and (5) providing aeronautical development support to other government agencies and U.S. industry. Additional emphasis has been given to emerging technologies with potential for order-of-magnitude advances in capability or performance. The far-term focus of the program provides results well in advance of specific applications and provides long-term, independent research and technology which is not driven by the development and operational pressures often encountered by the Department of Defense (DOD) and industry. Both fundamental research in the aeronautical disciplines and systems research directed at interaction among disciplines, components, and subsystems applicable to general classes of advanced aircraft are included. The program involves participation by aeronautical manufacturers from the industrial base to ensure that the technology is compatible with practical design considerations and to effect a rapid transfer into superior military and civil aircraft.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The aeronautical research and technology program reflects no change in total funding from the original budget request; however, the FY 1986 program has been adjusted to accommodate authorization action in the aeronautics program. Funding for the research and technology base is increased by $1.0 million by reallocation from high performance aircraft systems technology/oblique wing technology. In addition, there are reallocations as a result of several actions taken within the research and technology base. The altitude wind tunnel effort is reduced by $2.0 million and the activities will be brought to a logical conclusion in FY 1986. The specific recommendation in the FY 1986 authorization conference report to reduce research efforts in wind tunnel adaptive wall and model magnetic suspension have been accommodated. Rotorcraft research and technology has been maintained at the FY 1985 level of activity. The funding for high-speed aeronautics/hypersonics has been increased by $5.7 million to focus additional effort in critical technologies. Systems technology programs are reduced because $1.0 million of the funding for oblique wing technology has been reallocated to the research and technology base, consistent with the authorization action.

BASIS OF FY 1987 FUNDING ESTIMATE

The FY 1987 estimate is based on an increased effort to aggressively pursue the highest payoff technologies with potential for order-of-magnitude advances in capability or performance. A unique opportunity in high-speed flight is focusing substantially increased emphasis in generic hypersonic technologies supporting the transatmospheric research and technology program for a potential future aerospace plane. Subsonic transport and rotorcraft needs are addressed primarily through fundamental research aimed at the critical technology areas. Key high-performance aircraft technology efforts are accelerated, and a small effort in supersonic cruise technology is being maintained. The estimate also reflects the need to continue important efforts in the fundamental aeronautical disciplines and systems research and to support specialized facilities essential to aeronautics research.

The base research and technology program includes generic research which is broadly applicable to all classes of aircraft (general aviation/commuter, transport, rotorcraft, supersonic cruise, fighter/attack, and hypersonic) and focused research which is specific to one class of aircraft. Systems technology programs are more focused in applications and/or have the characteristics of specific projects, i.e., advanced turboprop, X-wing, and oblique wing. Funding for the technical operations of wind tunnels, propulsion facilities, computational facilities, simulators, and flight research operations is covered in the most appropriate discipline elements of the research and technology base. In FY 1987 research and technology base funding will support the operating cost for the numerical aerodynamic simulation (NAS) program, and systems technology funding covers the final NASA commitment to the X-wing program. A brief summary of some of the major thrusts for both the research and technology base and systems technology programs follows.

In fluid and thermal physics research, strong emphasis will continue on three-dimensional computational fluid dynamics (CFD) methods that will increase the speed and efficiency of flow solvers by two orders of magnitude and on novel techniques and devices to reduce aircraft drag by up to 60 percent. Benchmark experiments for CFD code validation and turbulence modeling will be strengthened.

Applied aerodynamics research efforts in high angle-of-attack aerodynamics will include wind tunnel and flight evaluations to improve the understanding of performance in both the low- and high-speed flight regimes and to correlate with predictions. Research efforts in test techniques will address laser holographics and nonintrusive measurement techniques which will provide an order-of-magnitude improvement in test accuracy.

In propulsion and power research, continued attention will be given to the technologies for small engines which will enable up to 50-percent improvement in fuel efficiency. Internal computational fluid mechanics efforts will address the physical modeling of complex internal flows and the validation of codes as part of the goal to reduce calculation times by an order of magnitude. Supersonic combustion ramjet (scramjet) and combined cycle engine research will be strengthened to address the technologies critical to the flight of high-speed vehicles from takeoff to orbital speeds.

Materials and structures research will increase in the area of composite materials, which can provide up to a 50-percent weight savings for future aircraft. Initial efforts will focus on thermoplastics and ceramic-matrix composite materials, as well as structural concepts exploiting their anisotropic properties. Research emphasis will also be increased in high-temperature materials and structures and thermal-barrier coatings with high-erosion resistance. A focused effort will be initiated in rotorcraft airloads to correlate noise and vibration predictions as part of the goal to reduce noise and vibration by 80 percent.

Information science research will continue to focus on flight-crucial software and concurrent processing to provide an order-of-magnitude improvement of efficiency and reliability. Controls and guidance and human factors research will focus on the application of artificial intelligence technology to enhance the operations of future aircraft. Increased emphasis will be placed on controls research for highly maneuverable aircraft. Human factors research will continue to address the critical man-machine interface issues which affect the safety and operational limitations of aircraft.

Flight systems research will provide focus on highly maneuverable aircraft capable of high angle-of-attack operation at low speeds, high-speed maneuverability, and short takeoff and vertical landing. Analytical and experimental investigations will be conducted on thrust-vectoring concepts to enhance high angle-of-attack maneuverability. Supersonic vertical/short takeoff and landing (V/STOL) concepts will be studied as the initial part of a joint United States/United Kingdom (U.S./U.K.) program. Other studies, conducted as part of the systems analysis effort, will determine the overall benefit of synergistic integration of component and subsystem technologies for hypersonic aircraft applications.

Rotorcraft systems technology efforts will include publication of an external noise prediction methodology aiming toward a three order-of-magnitude increase in accuracy and wind tunnel testing of an advanced bearingless rotor. Activities in technology for next-generation rotorcraft with more than a twofold increase in speed will be focused on completion of flight testing of the X-wing rotor system on the rotor systems research aircraft to include conversion from rotary to stopped-rotor flight mode.

Areas of continued emphasis in high-performance aircraft research are high angle-of-attack, with initial testing up to 20 degrees, integrated propulsion/flight controls to allow 10-15 percent performance improvements, supermaneuverability, short takeoff and vertical landing technology, and forward swept wing technology. The oblique wing technology program, being conducted jointly with the Navy to exploit the potential for high performance at subsonic and supersonic speeds, will include the detailed design and fabrication of the oblique wing and associated modifications of the NASA F-8 aircraft. Flight testing is planned to begin in FY 1989. Ceramic and ceramic-matrix research for turbine engines with operating temperatures up to 2300 degrees Fahrenheit will continue, along with the development of the analysis tools to accurately predict the life and assess the durability of turbine engine hot section components.

In the advanced turboprop program, aimed at a 30-percent reduction in transport fuel consumption, flight testing of the large-scale single-rotation propeller to build a performance data base for high-speed propeller aerodynamics and structures will be conducted. Geared counter-rotation propeller model tests will also be conducted. The general aviation/commuter engine research will include the definition of reference engines to focus and drive component technology development to large-engine performance levels and to provide a quantitative measure of the performance impact of advances as they are made.

In the NAS program, the initial operating configuration and the second high-speed processor for the extended operating configuration, allowing four to six times more computing power, will be installed in the new NAS facility. All subsystem upgrades will reach full capability early in FY 1989.

BASIS OF FY 1987 FUNDING REQUIREMENTS

RESEARCH AND TECHNOLOGY BASE

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Fluid and thermal physics research and technology...........................	28,498	48,500	30,400	39,500	RD 13-7
Applied aerodynamics research and technology...........................	50,900	43,700	55,300	57,100	RD 13-11
Propulsion and power research and technology...........................	33,636	31,000	33,800	35,700	RD 13-15
Materials and structures research and technology...........................	27,800	28,000	29,500	39,000	RD 13-19
Information sciences research and technology...........................	21,100	22,500	24,900	26,800	RD 13-24
Controls and guidance research and technology...........................	20,600	22,100	22,100	24,500	RD 13-26
Human factors research and technology...........................	20,300	22,000	22,000	24,000	RD 13-30
Flight systems research and technology...........................	17,864	18,300	18,300	21,500	RD 13-33
Systems analysis......................	2,600	3,200	4,000	4,800	RD 13-36
Total...............................	223,298	239,300	240,300	272,900	

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Fluid and thermal physics research and technology.........................	28,498	48,500	30,400	39,500

OBJECTIVES AND STATUS

The fluid and thermal physics research and technology program is a combined analytical and experimental research effort directed at external aerodynamics. One of its principal objectives is the development of computational methods, which will increase the speed/efficiency of three-dimensional (3-D) flow solvers by two orders of magnitude for the prediction and/or simulation of complex fluid flows over aircraft. A second objective is the validation of prediction and simulation methods, with particular focus on accurate 3-D turbulent models for attached/separated flows by means of a coordinated experimental test program. This activity provides improved insight into the fundamentals of flow physics, as well as the detailed flow measurements required for verification of the computations. Other program objectives include establishing a detailed aerodynamic data base for new high-performance transport aircraft configuations and conducting drag reduction research with emphasis on developing specific devices and design techniques to reduce overall aircraft drag by up to 60 percent. Rapid progress is being made in the development of computational and experimental techniques that will lead to reduced development time and costs for future aircraft and will provide the basis for achieving new and higher levels of aircraft and missile performance.

The goal of computational fluid dynamics (CFD) research is to develop advanced computational methods for predicting the aerodynamic flow field for complete aircraft/missile configurations under all conditions of attitude, speed, and altitude. To this end, the program includes the development of computer codes for simulating turbulence and for solving complex fluid dynamics problems including steady and unsteady, inviscid and viscous flow over two- and three-dimensional geometries from low subsonic to hypersonic speeds. Improved algorithms for Euler and Navier-Stokes codes are being developed; in particular, a transonic thin-layer Navier-Stokes solution for fighter-like wing-body configurations has been perfected. Vectorizable algorithms are being developed for efficient use of new supercomputer technology to make possible early utilization of the advanced capabilities provided by the initial operations of the numerical aerodynamic simulation (NAS) program. In this respect, significant progress has been made in linking gas dynamics and chemical kinetics in codes that will simulate the viscous, real-gas, external flows about hypersonic flight vehicles. The advancement of CFD research relies heavily on a detailed understanding of flow physics which provides input for more accurate mathematical modeling of the flow. Increased effort has, therefore, been devoted to the modeling of turbulence, which dominates many complex flows and remains one of the most vexing of all aerodynamic phenomena.

Increased emphasis has been placed on drag reduction research because drag reduction equates directly to fuel savings and improved aircraft range/payload performance. Significant progress has been made in skin friction drag reduction research. Passive techniques have provided appreciable drag reductions in pressure gradient flows, and the performance of the riblet and large eddy break-up devices has been shown to be additive at high Reynolds numbers. In natural laminar flow research, the effects of engine noise-induced acoustic disturbances on the maintenance of laminar flow have been investigated in flight. The results indicate that the benefits of laminar flow achieved by wing surface contouring will not be negated by engine noise. Laminar flow control research on the JetStar leading-edge flight test aircraft has progressed to the investigation of environmental effects under realistic operational conditions. The test aircraft has operated from the Atlanta and Pittsburgh airports, and the simulated operational environment testing will be moved to Cleveland for winter environment investigations.

Experimental and analytical aerodynamics research is centered around the testing and analysis of aircraft components and configurations. Although analytical methods for attached and vortical flows have been improved dramatically, experimental tests must be performed to validate new designs and prediction techniques and to obtain off-design data that cannot yet be calculated. Analytical techniques for separated, high angle-of-attack flows have emerged as useful design tools. Advanced supercritical technology and transonic computational methods have been generated and integrated into wing and canard design methods for high performance aircraft. As a result of recent progress in subsonic airfoil research, special purpose designs can now be rapidly and accurately generated. Recent examples include a medium-speed, benign-stall general aviation airfoil and a high-speed, shock-free airfoil.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $18.1 million in this program primarily reflects the transfer of fundamental aeroacoustics, test techniques, and national transonic facility (NTF) operations costs ($12.5 million) to applied aerodynamics and the transfer of internal computational fluid mechanics ($5.0 million) to propulsion and power for management and budgeting purposes. The transfer of laminar flow integration activities ($2.4 million) from the applied aerodynamics line has been offset by consolidation of the Ames Research Center's central computer facility costs into the information sciences line. In addition, $0.6 million was transferred to applied aerodynamics in support of priority hypersonics research and technology.

BASIS FOR FY 1987 ESTIMATE

In FY 1987, support of NAS operations will increase to reflect accelerated utilization of enhanced NAS capability. The CFD program will continue to emphasize improved 3-D configuration analysis and design. This will be principally accomplished through the development of numerical algorithms with an order-of-magnitude improvement in speed and efficiency over current solvers. Particular focus will be given to validating Navier-Stokes prediction codes for unsteady rotorcraft aerodynamics and codes incorporating real gas effects and finite-rate chemistry to predict aerodynamic performance, heat transfer, and engine/exhaust flows for hypersonic vehicle concepts. In addition, development of applications codes will be broadened to include greater integration among aerodynamics, structures, propulsion, and controls.

Increased emphasis will be placed on experiments designed to validate CFD techniques and to provide data for flow modeling. Data will be acquired to improve the modeling of complex flows which experience separation, vortical motions, and streamwise/transverse curvature.

Research to achieve significant reductions in overall aircraft drag will emphasize in FY 1987 the flight testing of a number of skin friction reduction concepts. Transonic and supersonic flight tests will be performed on riblets, which are longitudinal grooves that have shown significant turbulent drag reductions in wind tunnel tests. Another surface geometry modifier which has shown promise in ground-based testing is the large eddy break-up (LEBU) device. Transonic flight tests of the LEBU will be accomplished on the Langley B-737 aircraft. Supersonic viscous flow research will be increased with detailed wind tunnel investigation of boundary layer transition sensitivity to incident noise, roughness, waviness, and other disturbances. Additionally, a supersonic stability prediction method will be calibrated in the pilot low-disturbance wind tunnel. Other efforts in viscous drag research will include the F-14 variable sweep transition flight experiment on a natural laminar flow wing glove, completion of the JetStar laminar flow control flight tests, and supersonic laminar flow fundamental experiments on the Langley F-106 and the Ames-Dryden F-15 aircraft. New research into the reduction of induced drag (drag due to lift) and form drag will be initiated, to be followed shortly by research on wave drag reduction in which leading-edge modifications will be studied. Theoretical efforts in drag reduction will include development of a fully three-dimensional subsonic/supersonic viscous flow design code and the generation of near-field acoustic theory to model the interaction of noise with boundary layers.

A significant milestone in experimental aerodynamics projected for FY 1987 will be the completion of the Ames fluid mechanics laboratory. Fundamental tests and analyses will be conducted in this facility in unsteady boundary layers, vortical flows, advanced test techniques, and a variety of other flow physics phenomena. The theoretical efforts will be closely integrated with the corresponding experiments, which will be conducted primarily for the validation of computational aerodynamic methods and the exploration of fundamental flow mechanisms. The acquisition of detailed data to support turbulence model development will be pursued. Improved analysis/design capability for supercritical flows and vortical flows will be developed. In the Ames fluid mechanics facilities and in other aerodynamic research facilities, such as the national transonic facility, a major effort will be made to improve the transonic performance of advanced aircraft and missile configurations and to improve the understanding of high Reynolds number flows. Wing vortical flows will be analyzed in detail to develop prediction methods for high angle-of-attack flows and other complex phenomena. Supercritical technology and analytical transonic methods will be developed and applied to wing and canard design at cruise and maneuver conditions for advanced aircraft. Leading-edge extensions and cavity flap concepts will be explored to capitalize on vortex-thrust and vortex-lift phenomena. Airfoil research will include basic aerodynamic tests of a swept porous laminar flow control airfoil and complete performance testing of a natural laminar flow airfoil. A high-lift data base will be established for an advanced four-component airfoil, with special attention given to confluent boundary layer behavior.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Applied aerodynamics research and technology...........................	50,900	43,700	55,300	57,100

OBJECTIVES AND STATUS

The objective of the applied aerodynamics research program is to generate, by conducting analytical and experimental programs relevant to specific vehicle classes, advanced technology to improve performance and flight dynamics of future aircraft and missiles. The program is directed at specific technology goals associated with particular types of vehicles: (1) increased efficiency for subsonic aircraft through airframe/propulsion integration, stall-spin resistance, improved takeoff and landing performance, and a 60-percent reduction in cruise drag; (2) accurate prediction and reduction of rotorcraft noise and vibration, and improvement of rotorcraft performance permitting a fivefold increase in productivity; (3) high angle-of-attack maneuverability, sustained supersonic performance, and short takeoff and vertical landing (STOVL) capability for high-performance aircraft; (4) a 50-percent increase in lift-drag ratio for supersonic cruise aircraft; and (5) a 40-percent increase in hypersonic lift-drag ratio for hypersonic/ transatmospheric vehicles. These programs utilize a broad variety of test facilities and are supported by continuing development of test techniques and instrumentation. The objective of the test techniques research is to improve experimental capability and to achieve an order-of-magnitude improvement in the accuracy of wind tunnel data. In addition, the program includes aeroacoustics research that develops the basic understanding required to examine specific noise problems such as the effect of advanced turboprop noise on structure and laminar flow.

In subsonic powered-lift research, the current emphasis is on large-scale testing of new concepts, including some in cooperative programs with industry, the Department of Defense (DOD), and allied governments. A large-scale model of the subsonic Grumman 698 tilt fan (V/STOL) aircraft is being readied for cooperative NASA/Navy testing in the 80x120-foot wind tunnel. Planning is in progress for cooperation with the DOD in further technology development for future aircraft such as the advanced technology transport being considered by the U.S. Air Force.

The emphasis in the rotorcraft aerodynamics research program is to provide technology required for low vibration for safety, speed, durability, and comfort and for the design and certification of civil and military helicopters producing 80 percent less noise than current helicopters. Basic acoustic analysis is showing promise for the reduction of certain types of noise, but higher order computer codes and experiments are needed to provide the accuracy required for design and certification of improved rotorcraft. In vibration research, cooperative efforts with industry have shown the need for structural detuning between the rotor and the fuselage and the need for better modeling of fuselage modes. Fundamental to these efforts are several small-scale wind tunnel tests for rotor airloads and interference. In full-scale flight research, the rotor systems research aircraft will complete a high-speed rotor performance survey. Support for the advanced light helicopter (LHX) and the V-22 programs continues, using the upgraded 40x80-foot wind tunnel and the XV-15 tilt rotor aircraft. In general aviation research, with spin-resistant design technology sufficiently developed to support the Federal Aviation Administration (FAA) certification of single-engine airplanes, the focus is shifting to twin-engine aircraft. The natural laminar flow research for drag reduction continues, emphasizing propeller slipstreams and three-dimensional fuselage shapes. Newly developed liquid crystal coatings will aid this effort by providing instantaneous measurement of fluctuations of boundary layer transition.

The high-performance research program is examining three high payoff areas for aerodynamic investigation: (1) sustained supersonic cruise; (2) high angle-of-attack maneuverability; and (3) vertical lift operation. For supersonic cruise, nonlinear, attached-flow computer codes for optimum design of supersonic configurations are being developed. Store carriage and separation at supersonic conditions are also being investigated, with emphasis on cavity flows with experimental validation. In high angle-of-attack research, analytical methods for calculating the typical vortex and separated flows from aircraft at high maneuver angles are being developed, with subsonic tests being used for correlation. Active control with blowing and passive design techniques are both being investigated for improving the control problems associated with this maneuver condition. In addition, the use of multiaxis thrust vectoring is being explored after successful free-flight tests in the 30x60-foot wind tunnel. These fundamental efforts are closely coupled with the research flight experiments conducted under the systems technology element for high-performance flight research. In supersonic fighter STOVL, a generic ejector lift model is investigating augmentation concepts, and an ejector lift/vectored thrust fighter model is being constructed in large scale by Canada for testing by NASA in a cooperative program. In addition, in-house studies of other supersonic STOVL concepts are underway for tandem fan and remotely augmented lift system concepts.

Activities in hypersonics were expanded in FY 1986 in both the experimental and theoretical areas. The Langley Research Center program addresses the experimental wind tunnel model testing of advanced configurations that show promise for application in atmospheric cruise and airbreathing launch vehicles. The Ames Research Center activities concentrate on the application of computational fluid dynamics to the simulation and analysis of complex flow fields.

In support of the above efforts, new testing capability and techniques are being pursued. The national transonic facility is continuing to demonstrate capability for cryogenic wind tunnel testing in order to simulate full-scale conditions with independent control of compressibility, viscosity, and aeroelasticity parameters. Models tested to date include the space shuttle, the EA-6B for the Navy, and the Pathfinder I, a generic transport with interchangeable components. Increased emphasis is being placed on nonintrusive measurement devices, such as lasers, with large payoffs in accuracy and productivity. In the aeroacoustics research effort, flight testing has been conducted to determine the effect of engine acoustic loads on the natural laminar flow of a nearby wing, and an effort is in progress in supersonic plume flow to examine the acoustic fatigue loads on the aft end of high-performance fighters.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The increase of $11.6 million resulted from the realignment of fundamental aeroacoustics, test techniques, and NTF operations costs ($12.5 million) to this program and a general increase of $1.5 million, $0.7 million of which supports hypersonics technology. These increases were partially offset by the transfer of laminar flow integration research ($2.4 million) to fluid and thermal physics.

BASIS OF FY 1987 ESTIMATE

FY 1987 activities in rotorcraft aerodynamics research will include the acquisition of aerodynamic interference data on a main rotor/fuselage/tail rotor test apparatus in the 40x80-foot wind tunnel. A bearingless main rotor will be tested to define high-speed dynamic stability and loads. A simplified method of higher harmonic control for vibration reduction will be tried on a full-scale rotor in the 40x80-foot wind tunnel. Initial runs of a three-dimensional, viscous, transonic, unsteady flow analysis will be made for rotor blade tips.

High-performance aerodynamic research in sustained supersonic cruise will continue to develop analysis and experimental correlation of supersonic wing design and store carriage and separation. High angle-of-attack maneuverability research will investigate stability and control at angles to at least 80 degrees and will focus on three areas: (1) development of a data base for improved understanding of flow and flight dynamics phenomena and for subsequent support of planned flight research on the F-18 vehicle for high angle-of-attack testing; (2) aerodynamic data necessary for piloted simulations of maneuvers using thrust vectoring for control; and (3) the effect of vortex flaps on the control system requirements.

In powered-lift technology, the large-scale fighter model [illegible] an ejector lift/vectored thrust model will be tested in the 40x80-foot wind tunnel in a cooperative [illegible]fort with Canada. Several studies and tests on critical technology areas such as sustained supersonic cruise and ground-effect penalties in hover will be undertaken in support of the U.S./United Kingdom program in supersonic STOVL. Simulation of the proposed STOVL concepts will determine required levels of control power and flying qualities.

The FY 1987 general aviation research will emphasize the acquisition of aerodynamic data in support of research on automatic control of engine-out conditions on twin-engine airplanes. It will also include research on unconventional configurations using forward sweep, canards, and aeroelastic tailoring. Criteria for fuselage designs having natural laminar flow will be developed. In the area of test techniques and instrumentation, the national transonic facility will continue development of advanced cryogenic instrumentation with emphasis on accurate boundary layer diagnostics, sensing of model attitude and structural deformation, and the development of an ultra-high force balance. In other test techniques activity, laser holography visualization will permit the calculation of turbulence quantities. Adaptive walls will be operational in the Langley Research Center 0.3-meter and the Ames Research Center 2-foot wind tunnels. Fluorescent techniques will be developed for sensing temperature, density and skin friction parameters. The liquid crystal coatings for boundary layer research will be extended to supersonic and hypersonic flows.

The FY 1987 aeroacoustics research for fixed wing aircraft will continue the study of supersonic plume dynamics. This effort will be used in the analysis of ground and F-15 flight experiments that are investigating the structural fatigue loads associated with the acoustics of the dual-engine installation.

Hypersonic cruise/transatmospheric concepts will be designed, tested, and analyzed to establish a data base for this evolving vehicle class. Wind tunnel models will be constructed and tested over a wide speed range, (through hypersonic Mach numbers) to high altitudes over a range of Reynolds numbers at the Langley Research Center. The computational fluid dynamics program at the Ames Research Center will be expanded to include real gas effects and the effects of flow-field separation on realistically complex aerodynamic shapes.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Propulsion and power research and technology..........................	33,636	31,000	33,800	35,700

OBJECTIVES AND STATUS

The objective of the propulsion and power research and technology program is to provide the understanding of the governing physical phenomena occurring at the disciplinary, component, and subsystem levels that will support and stimulate future improvements in propulsion system efficiency, performance capability, fuel flexibility, reliability, and durability. Research is being performed on a wide variety of subsystems with application ranging from the general aviation class through the hypersonic/transatmospheric class of aircraft. Ongoing disciplinary research on instrumentation, internal computational fluid mechanics and aerothermodynamic concepts is providing the foundation necessary to support progress at the component and subsystem levels. These efforts will lead to major propulsion system improvements for all types of aircraft.

Hypersonic propulsion research has as its objective the maturing of supersonic combustion technology to support development of future systems. Near-term goals are the demonstration of good high-speed performance and, through a series of well thought-out experiments, the development of an understanding of the concept's governing principles. In FY 1985 a step-strut scramjet engine module operating at Mach 4 demonstrated a 21-percent increase in thrust over previous configurations and eliminated the combustor-inlet interaction previously observed. Tests will be run in FY 1986 to verify performance at Mach 7. Piston-driven shock-tunnel simulations for scramjet combustor conditions were carried out and showed good correlation with well established theoretical predictions proving it a useful tool for obtaining skin friction, wall heat transfer, and flow visualization. The reaction enhancement properties of silane were also demonstrated, providing a means to expand the envelope of conditions in which reactive tests can be conducted. Checkout measurements of temperature and concentration of nitrogen and oxygen in a subsonic flame using coherent anti-Stokes Raman spectroscopy were successfully completed proving this instrument ready for use on a supersonic flame.

For supermaneuverability and powered-lift applications, in which the goal is the development of technology to support propulsion systems capable of powered-lift and in-flight thrust vectoring capability, work is focusing on understanding ejector applications and the effects of thrust vectoring. The vectored-thrust model intended for determining thrust-vectoring performance and inlet ingestion is scheduled for testing in the Lewis Research Center 9x15-foot wind tunnel. Fabrication of a new powered-lift test rig at the Lewis Research Center will be completed in FY 1986 for later testing of the air ducting of a representative ejector system. Fabrication of a short diffuser for a supersonic 2-D inlet is near completion and will be tested to determine if engines can be installed farther forward on aircraft to get them closer to the center of gravity for improved control.

In small engines the objective is to achieve a specific fuel consumption reduction of 50 percent and, in addition, a multifuel capability for rotary engines. Near-term emphasis for the rotary engine is to obtain sufficiently improved understanding of the physical processes to enable accurate performance predictions and determination of advanced engine operating boundaries. For small gas turbines the specific fuel consumption goal can be met through the use of improved materials and advanced aerodynamic design, the concepts of near-term focus. The computer modeling for performance and heat transfer analyses of direct injection stratified-charge rotary engines has been completed, and the finite-element stress model for determination of the rotor and housing stresses was made operational. Castings of graphite-reinforced magnesium, for housings, which will provide increased stiffness for improved sealing, were successfully fabricated. The baseline performance characterization and evaluation of a high flow rate, low fuel injection, and high-voltage ignition system stratified-charge rotary test rig were initiated and will be completed in FY 1986.

Instrumentation research is progressing toward advanced high-temperature sensors and optical nonintrusive measurement systems. The first optical instrumentation system that allows flow measurement of all three velocity components through a single viewing port has been fabricated and successfully bench tested. The system is capable of measuring complex flows in turbomachinery passages, thus making possible a fundamental understanding of secondary flows. The system will be used to generate detailed secondary flow measurements during compressor tests in FY 1986. An advanced optical pressure sensor that is capable of operation at temperatures up to 840 degrees Fahrenheit was also demonstrated.

Internal computational fluid mechanics (ICFM) is emerging as a highly important tool for improved understanding of flow physics and for application in aeropropulsion systems. This will prove increasingly true as the ability to calculate complex three-dimensional flows with fast, validated techniques improves. Toward this end, improvements are sought in algorithm speed, ability to predict important physical phenomena, and proper validation of the prediction techniques. In FY 1985 a three-dimensional inviscid code was developed and used to analyze a radial flow turbine to determine secondary flow components, and rigorous viscous subsonic compressible flow analysis for two-dimensional and axisymmetric ducts has been developed that allows calculation of fully developed turbulent flows. The Institute for Computational Mechanics in Propulsion is now operational, and the first two institute members are on site at Lewis Research Center performing algorithm development research. The Lewis Research Center operates a Cray XMP computer system to provide state-of-the-art high-performance computational facilities for aeronautics research in fluid dynamics and heat transfer.

RD 13-16

CHANGES FROM FY 1986 BUDGET ESTIMATE

The increase of $2.8 million reflects the transfer of internal computational fluid mechanics research ($5.0 million), offset by a reduction of $2.2 million in altitude wind tunnel modeling support and other study efforts; $1.5 million of this latter amount was transferred to the materials and structures line in support of priority hypersonics technology efforts. In addition, $2.9 million is being directed toward hypersonics technology requirements within this program.

BASIS OF FY 1987 ESTIMATE

The hypersonic propulsion activities will continue with design and fabrication of the large-scale scramjet engine hardware to show that the technology which was recently demonstrated can be applied to larger-scale engines. Low-speed performance will be verified with wind tunnel tests at both subsonic and low supersonic speeds. Coherent anti-Stokes Raman spectroscopy will be used to obtain instantaneous measurements of turbulence and heat release for aid in future model development. This will be the first time this information is obtained in a turbulent supersonic flame. Hydrogen injection into a Mach 18 flow will be investigated using the newly validated shock tunnel to obtain combustion and mixing rates for developing an understanding of the physics at extremely high speeds. The joint NASA/Defense Advanced Research Projects Agency (DARPA) program on combined cycle engines will continue into the fabrication phase.

In supermaneuverability and powered-lift propulsion technology for vertical and short takeoff and landing applications, determination of the performance of the U.S./Canadian ejector model for thrust augmentation will be conducted in FY 1987. The ejector system will be calibrated at the Lewis Research Center prior to testing with air flow in the 40x80-foot wind tunnel at the Ames Research Center. The complete General Dynamics E-7 ejector system will be tested at the Lewis Research Center on the new powered-lift rig to determine the details of pressure drop and flow distribution on a representative configuration. Testing of the vectored-thrust model for hot gas ingestion evaluations will be completed in FY 1987.

Under small engines, designs will be completed on rotating and stationary components for small gas turbines utilizing materials such as ceramic and ceramic composites that will enable the system to operate at higher temperatures with minimal cooling for increasing cycle efficiency and reducing cooling penalty. Development will begin on analytical 3-D viscous codes with moving coordinates which will guide new designs for high-efficiency components for high-temperature and stress conditions. In intermittent combustion research, the digital electronic high-pressure fuel-injection system design will be completed and fabrication begun. Comparison between the baseline performance of the rotary test rig and computer model will be complete and improvements to the code undertaken. High wear-resistant inserts will be cast into the graphite-reinforced magnesium housings to provide a better seal surface.

In the area of advanced instrumentation research, with its focus on high-temperature sensors for use with ceramics and other high-temperature materials, research will be continued on development of technology for high-temperature electronic devices based on silicon carbide. Emphasis is on improving crystal purity, obtaining a new crystalline structure capable of operation at 600 degrees centigrade, and the successful fabrication in FY 1967 of a silicon-carbide diode.

Research emphasis in ICFM will be placed on advanced algorithm development to decrease computation time for high-speed flows, by investigating efficient techniques for use with parallel processors, and to extend state-of-the-art external flow algorithms to internal flows, in particular, those with periodic unsteadiness as occur in turbomachinery. Additional emphasis will be placed on grid generation techniques to eliminate errors that can develop in calculations of high-speed flows by small grid errors occurring in the extremely thin shock layer regions. In addition, advanced computational techniques will be applied in areas of special interest including unsteady flows with shear layers to investigate the effect of shear layer excitation on mixing control; critical physical phenomena for high-speed flows to determine the characteristics and extent of imbedded regions, such as subsonic pockets; two-phase mixing flows to study ways to improve combustion and determine stability boundaries; reacting flows including chemical kinetics and heat transfer; and detailed experimental studies of highly sheared flows. Benchmark validation experiments will be performed for high Mach number flows in complex ducts, variable geometry supersonic inlets, and unconventional variable geometry nozzles with expansion on the vehicle afterbody.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Materials and structures research and technology........................	27,800	28,000	29,500	39,000

OBJECTIVES AND STATUS

The objectives of the materials and structures research and technology program are to: (1) investigate and characterize advanced metallic, ceramic, polymer, and composite materials; (2) develop structural concepts and design methods to exploit the use of advanced materials in aircraft; (3) advance analytical and experimental methods for determining the behavior of aircraft structures in flight environments; and (4) generate research data to promote improvements in performance, safety, durability, and economy in aircraft. Areas of emphasis include high-temperature engine and airframe materials and structural concepts; composite materials application, life prediction, and thermal and dynamic response, including aeroelasticity; and more accurate and efficient integrated design methods for airframes and engines.

Significant improvements in the performance of turbine engines and airframe structures can be realized through research in the rapid solidification of metals. Ongoing studies are directed toward developing a greater understanding of the interrelationships among alloy composition, microstructure, processing parameters, and mechanical properties. This is particularly important in the exploitation of the innovative rapidly solidified superalloys and intermetallics now under study for high-temperature application. The opportunity for an operating temperature increase of up to 200-degrees Fahrenheit appears possible. Furthermore, recent results indicate that rapidly solidified aluminum powder alloys can be processed to achieve 20 percent greater strength-to-weight ratios with acceptable toughness for advanced airframe application.

Advances in structural mechanics are required for design verification of efficient, fault-tolerant advanced composite aircraft structural concepts subjected to various loads and discontinuities. Computational structural mechanics, a major thrust beginning in FY 1986, is focused around the development of advanced structural analysis and computational methods that exploit advances in computer hardware such as the application of multiple processors and concurrent processing capability. Initial studies address analysis problems of large displacements in flat and curved stiffened composite panels.

Analytical studies with experimental validation testing have continued to show that composite panels can exhibit substantial post-buckling strength of up to 80 percent of the unbuckled strength under combined compression and shear loading. Interior damage mechanisms for quasi-isotropic laminates subjected to bending have been characterized with and without open cutouts. Advances in nonlinear analysis capability to predict compressive strength in thick sections continue to be made with significant progress in code development.

The aeroelasticity program continues to develop and validate the technology required for active control of structural response for increased aircraft performance through relaxed static stability, flutter suppression, and gust load alleviation. Theoretical and experimental studies on unsteady aerodynamics, with major emphasis on the transonic region, have developed the capability for accurate analysis of a thick supercritical transport wing. Advanced nonlinear code development has been successfully extended to include strong shock conditions and the effect of oscillating control surfaces and has been correlated with wind tunnel results.

Research on composite materials places high emphasis on the toughness and durability of highly loaded structures. New materials, including semicrystallines and hybrids, have been developed to be 50 percent more resistant to impact and fracture through a better understanding of the relationships between material/structural mechanics and the molecular structures. Research on advanced structural concepts and configurations that exploit the advantages of composite materials continues. The primary effort is focused on the prediction and correlation of structural behavior of post-buckled stiffened composite panels and development of failure theories for composite structures.

The research program to develop ceramic materials for hot section components for gas turbine engines is continuing. Ceramics provide for higher temperature capability than metals (up to 2300 degrees Fahrenheit) but currently suffer from reliability problems. During FY 1986 processing studies for flaw-free silicon-nitride and silicon-carbide materials continued to show advancement. Research into the fabrication of ceramic composites for greater toughness was initiated. Considerable progress has been made in the understanding of the chemistry, kinetics and effects on strength of hot corrosion attack on silicon nitride. Fracture mechanics research has concentrated on the development of reliable crack growth characterization methods for monolithic ceramic materials at elevated temperatures. Initial results show promise for the development of improved models in these areas.

Hypersonic materials and structures research is a new area of emphasis in FY 1986. Innovative airframe and propulsion concepts are being explored. In both areas, research will be directed toward the development of new lightweight structural material systems that will withstand the extremely high temperatures and pressures encountered in the hypersonic flight regime. These systems include metallic and intermetallic composites for engine application and advanced titanium honeycomb, metal matrix and box-stiffened fuselage substructure concepts for airframe application. Advanced 3-D analysis codes which deal with complex thermal/structural/flow interactions are a major thrust of the research for this area. Analysis tools ranging from conceptual design evaluation through detail structural optimization will be developed.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The materials and structures research and technology program has been increased by $1.5 million to support hypersonics technology.

BASIS OF FY 1987 ESTIMATE

Research on high-temperature engine materials will emphasize improved durability and reliability of ceramics, thermal barrier coatings for turbine blades, and advanced intermetallics. Research efforts will focus on the development of a detailed understanding of the sintering, hot isostatic pressing, and powder processes in order to limit the number of strength-reducing flaws in high-temperature ceramic materials and achieve at least a doubling of the Weibull failure modulus. Increased emphasis will be placed on the development of tough ceramic and advanced intermetallic matrix composites and studies of matrix/fiber interface effects. New thermal barrier coatings with twice the resistance to erosion and foreign object damage will be identified. Advanced intermetallic alloys will be developed with a 40-percent ductility and strength increase at elevated temperatures.

Studies to understand the fundamental fatigue and fracture behavior of experimental and engineering materials will continue in order to develop reliable life prediction methods. The work will concentrate on the determination of the fatigue behavior of powder aluminum alloys and the development of fracture theories for these ductile metals. Special attention will be given to developing nonlinear analysis that predicts the growth rates of very short cracks. Advanced metallic fabrication concepts such as superplastic forming of high-strength aluminum will be developed to provide 40 percent lighter weight efficient airframe structures.

Composites research and technology efforts will emphasize toughness, durability, and processability of materials and low-cost, efficient, and highly loaded advanced structural concepts. In addition to the development and characterization of newer thermoset and thermoplastic resin systems, materials research will concentrate on advanced material forms and fabrication technology, such as 3-D weaving, to achieve a 100-percent increase in resistance to impact and interlaminar strength. Primary emphasis of the program will be to understand the interaction and relationship between new fiber and resin system properties and structural characteristics and failure modes, and to develop micromechanical behavior models.

In the structures area, significant effort will be devoted to the development of concepts and configurations which effectively utilize the anisotropic properties of composites to achieve the most efficient structural designs by a factor of two in terms of cost, weight, and damage tolerance. The major thrust of this effort will be the development of structural sizing and analysis methods based on structural tailoring for stiffness and strength at both the local and global levels. Local tailoring at sites of load introduction and discontinuities can have a significant impact on increased resistance to damage and weight advantages associated with joints, attachments, and local stress risers. Global or component level structural tailoring for stiffness and strength, including aeroelastic effects, provides major advances in structural weight efficiency and becomes interdisciplinary because of the attendant effects on flight controls and aerodynamics. The unconventional placement of composite material with highly directional properties to achieve the desired effects will require significant advances in understanding properties, loading effects, failure characteristics, and the development of 3-D analysis and prediction methods. New testing methods will be required to define failure models and verify analysis procedures.

The dynamics and aeroelasticity program will continue to emphasize the development of improved analytical tools for predicting unsteady aerodynamic pressures, particularly in the transonic speed range, and the aeroelastic response of wings and engine turbine blades. Analysis methods will be verified through systematic tests of both idealized and true-scale airfoils and will concentrate on nonlinear 3-D flow effects. This effort will provide the basis for a significant advance in the development of active control technology.

In the area of integrated analysis and optimization, efforts will concentrate on the development of methods in computational structural mechanics for the analysis of complex aerospace vehicles. Emphasis will be placed on methods for predicting nonlinear transient dynamics and on the development of new solution techniques that take advantage of advanced computer hardware/software concepts, e.g., parallel processing and hybrid analysis techniques. In addition, work will continue in the development of methodology for multidisciplinary design of aircraft vehicles. The number of parameters taken into account in the optimization procedures will be expanded to include vehicle aerodynamic shape and active controls, as well as structural design constraints. A focused study will be initiated to validate the approach on an advanced fighter configuration.

An augmented effort will concentrate on the detailed airloads experiments needed to correlate predictions of rotorcraft noise and vibration. Pressure-instrumented blades will be flown on the Boeing Model 360 and the UH-60 helicopters. Also, detailed pressure measurements will be taken of the new high-speed conditions in the 40x80-foot wind tunnel on a full-scale rotor. Simultaneous acoustic and loads measurements will be taken for the first time. This activity will be the beginning of the use of powerful computer codes and the comprehensive data bases that will lead to concepts for the desired 80-percent noise reduction and the reduction of vibration to transport levels. Promising noise and vibration reduction techniques will be pursued to demonstrate quiet, "jet-smooth" operation. The previous rotorcraft structural dynamic modeling results will form the basis for this effort. The other major technical thrust in this program will involve the development of rotorcraft-coupled rotor-airframe dynamic response prediction capability. This will then enable airframe structural optimization for complex vibration and acoustic loads. This activity will include the dynamic testing of all critical rotorcraft components to generate a comprehensive data base for validation of advanced analytical methods. The program will also allow unique rotor and airframe concepts to be defined and evaluated and will encompass efforts to enhance basic understanding of aeroacoustics, blade dynamics and aeroelasticity, and effective utilization of advanced materials for airframe design concepts.

In FY 1987, more emphasis will be placed on hypersonic research. Material and structural concepts to enable a high-speed, high-temperature vehicle will continue to be developed. Innovative fabrication schemes for ultra-lightweight, high stiffness and strength structures will be explored. Thermal/structural/flow analysis and multidisciplinary optimization techniques will be expanded to cover the entire flight regime. Evaluation of tankage concepts for cryogenic fuels and methods for active thermal management of integrated engine/airframe designs will be developed.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Information sciences research and technology........................	21,100	22,500	24,900	26,800

OBJECTIVES AND STATUS

The objectives of the information sciences research and technology program are to explore the fundamental principles underlying aerospace computing, to understand the relationship and tradeoffs between algorithms and computing architectures, and to develop advanced computational concepts and system architectures. The program supports research in concurrent processing, reliable computing, software engineering, and large-scale scientific computational facilities for aeronautics research.

Concurrent processing research addresses system architectures and algorithms for computationally intensive problems in aeronautics, such as computational fluid dynamics, computational chemistry, and structural dynamics. The benefits obtained from these computations are both essential and substantial but remain limited by the performance of the most advanced equipment and software. The concurrent processing work is concentrating on exploiting parallel processing techniques to increase computational power for aeronautics computations. In 1985 the ability to simulate parallel processing and architectures was demonstrated. This demonstration proved the concept and is the basis for continuing work along this line to improve the fidelity and the scope of the simulation. That simulation provides a powerful tool for developing improved computer software and architectures. Work is also underway to develop parallel and distributed computer systems that are practical for aerospace vehicles.

The Research Institute for Advanced Computer Science (RIACS) is just beginning the final year of its three-year start-up phase and has established itself in the nation's computing research community. Much of the effort is concentrated on analysis of new parallel processing computers. An Intel hypercube machine is now being used to support the research into the class of highly parallel machines that do not share common memory.

Software engineering work concentrates on the production of reliable software and computers. A study and experiment concerning the fundamental basis for fault-tolerant designs led to a surprising finding that redundant versions of software did not give nearly the expected improvement in reliability due to the fact that software faults are not independent. This important finding is the basis for additional studies and experiments with software and fault-tolerant designs. Work is underway to develop techniques for testing and verifying reliable software.

A major objective of the computer science and applications program is to provide state-of-the-art high-performance computational facilities for aeronautics research. Ames Research Center operates a Cyber 205 and Cray XMP-22 at the central computer facility. This system provides vital computational support to researchers in fluid dynamics, chemistry, and thermal and structural analysis.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The information sciences research and technology program includes an increase of $2.4 million, which reflects the consolidation of funding for Ames Research Center's central computer facility into this budget line.

BASIS OF FY 1987 ESTIMATE

In concurrent processing, work will focus on using concurrent processing to speed solutions to increasingly complex aerospace computational problems. RIACS will direct its energies on technology to greatly improve the productivity of aeronautics research scientists through computational systems employing artificial intelligence and very high-performance computing architectures. Computer science researchers at RIACS will work in conjunction with computational physics experts in advancing capabilities to solve aerospace computational problems.

Efforts initiated in FY 1985 will continue to involve universities in fundamental computer science research. Research areas include multiprocessor parallel architectures, distributed processing architectures, and multiple-instruction/multiple-data architectures for supercomputers. Techniques to automate the production, evaluation, and validation of software to enable the cost-effective production of highly reliable software are research topics.

Cooperation with DOD in software development will include interfaces with the Software Engineering Institute and software technology for adaptable reliable systems programs. Development of software engineering techniques needed to produce reliable and affordable software will continue with some emphasis on maximizing the benefits of utilizing the Ada programming language.

Support for the supercomputer facilities at Ames Research Center will be continued. Marshall Space Flight Center will complete development of a digital high-speed network to link agency supercomputer facilities at Lewis Research Center, Ames Research Center, and Langley Research Center. That capability will merge with the program support communications network and will become an operational network at the conclusion of the development.

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Controls and guidance research and technology.........................	20,600	22,100	22,100	24,500

OBJECTIVES AND STATUS

The objectives of the controls and guidance research and technology program are to: (1) develop advanced controls and guidance theories and analysis methods for extending the performance envelope and reliability of highly augmented future aircraft; (2) investigate emerging controls, guidance, artificial intelligence and display technologies which offer future alternative approaches for continued aviation safety, effectiveness, and efficiency; (3) develop architectures for flight-crucial systems for future aircraft and devise analytical methods and techniques for assessing the reliability and performance of complex integrated fault-tolerant systems; (4) develop methods for more efficient and safe transport aircraft operations in the national airspace system; and (5) explore new concepts for achieving integration of multidisciplinary technologies. Major generic program elements are control theory, guidance and display concepts, and flight-crucial systems. Vehicle specific program elements address subsonic transports, rotorcraft, high-performance aircraft, and hypersonic vehicles.

Control theory research includes activities on analytical methods, criteria and guidelines, controls modeling, and applications. Methods for analyzing and simulating reconfigurable/restructurable control systems continue to be a major focus, with the objective of automatic failure detection and identification, parameter estimation, and controller design to accommodate unanticipated failures in real time. Centralized and decentralized failure detection and identification (FDI) techniques are being investigated. The initial assessment of centralized FDI techniques indicates the orthogonal series generalized likelihood ratio method offers the most potential. Handling qualities criteria research, which has concentrated on new time domain methods for superaugmented aircraft, will be terminated at the end of 1986.

Guidance and display concepts research investigates advanced methods for achieving desired flight-path guidance in all-weather conditions and advanced display technology to improve the presentation of information to the flight crew. In the guidance concepts area, progress has been made in formulating approaches to utilize and apply artificial intelligence and expert systems technology in various aircraft applications. For military airplanes, the main thrust involves flight evaluations of "automated wingman" and advanced lead-pilot advisor concepts; for civil aircraft, the main emphasis is on an expert system to assist air traffic controllers. Display concepts research has focused on flat-panel displays, graphic display generation, and three-dimensional display techniques. A two-primary-color, thin-film, electroluminescent, flat-panel test specimen display was fabricated successfully for the first time using superimposed red and green phosphor layers.

Flight-crucial systems research has concentrated on the development of a technology base for the design, validation and assessment of highly reliable guidance and control systems which are critical for successful flight. The avionics integration research laboratory facility at the Langley Research Center is the focus for a significant part of this research, which has extensive industry and university involvement. Two new reliability analysis computer programs have been developed to improve assessment methodology for flight-crucial systems. One of these, the semi-Markov unreliability range evaluator, has received very favorable comments from industry because it is very fast and can directly utilize experimental data. The other, the hybrid automated reliability predictor, extends the capability of a previously released program which is widely used by aircraft manufacturers and guidance and control companies.

Controls and guidance research directly applicable to subsonic transports includes activities on advanced transport operating systems, airborne Doppler radar wind-shear detection, advanced digital control system architectures, and flight safety. A unique transport control system concept, called the total energy control system, was flight tested successfully in the transport systems research vehicle. This multi-input, multi-output control system design demonstated that throttle activity due to flight path perturbations could be reduced by integrating a full-time autothrottle to control the total energy of the aircraft with the elevator to distribute the energy between speed and flight-path angle. Extensive planning and coordination with the FAA has taken place to establish a practical integrated four-dimensional flight management/time-based air traffic control system program which would include experimental flight operations at one of the FAA's regional centers.

Rotorcraft guidance and controls research involves unique concepts to improve the overall effectiveness and utilization of rotorcraft for military and civil missions. A highly portable, low-cost beacon landing guidance system using airborne radar technology has been developed and successfully flight tested. The tests demonstrated that the system could provide precision instrument approach capability for helicopter operations at remote sites. In conjunction with this activity, NASA also has worked with the U.S. Air Force in the development and flight testing of a portable tactical approach guidance system which shows great promise for use in a battle-damaged airfield mission scenario for both fixed-wing and rotorcraft applications.

Controls and guidance research directly applicable to fighter/attack aircraft includes the integrated airframe/propulsion control system architecture program aimed at the development of validation methodology for complex integrated control systems and the multidisciplinary dynamics integration effort focused on functional integration of aerodynamic, structural, propulsive, and control system dynamics. In addition, research is underway on advanced automated air combat guidance laws for high-performance aircraft. Included are both heuristic and expert system approaches involving artificial intelligence techniques for automation of fighter/attack aircraft control and other functional tasks.

Hypersonic vehicle controls and guidance research is directed toward guidance and outer-loop control concepts which can significantly affect the performance and efficiency of hypersonic cruise vehicles operating at very high altitudes. Conventional guidance and control techniques may not be optimum at the upper atmospheric environment at which these vehicles will operate, and new considerations, such as extremely high temperatures, may dictate completely new primary guidance and control modes. Initial planning and conceptual research are now underway in this area.

CHANGES FROM FY 1986 ESTIMATE

The total funding for this program has not changed; however, $0.2 million has been redirected within the program to support hypersonics technology.

BASIS OF FY 1987 ESTIMATE

In the control theory area, research on reconfigurable/restructurable control systems has the goal of extremely highly reliable adaptation to failures. The emphasis on failure detection and identification techniques will shift from selected centralized methods to decentralized techniques and adaptive methods. Complementary research on systems identification aims to achieve real-time methods. Initial activities to merge expert systems techniques with modern control theory design methods will begin in the field of analytical design methodology.

Guidance and display concepts research includes the application of artificial intelligence technology to military and civil aircraft operations. The major focus will be the "automated wingman" program undertaken in cooperation with the Defense Advanced Research Projects Agency. The "automated wingman" concept has the potential for making substantial improvements in the effectiveness of multiaircraft strike forces through the application of artificial intelligence technology. The approach for conducting flight research in this program, involving a ground computational facility and a remotely augmented vehicle, offers the potential capability for rapid prototyping of complex aircraft and multiaircraft systems in a cost-effective manner.

In the flight-crucial systems area, research will stress validation techniques, assessment technology, software reliability, lightning effects, and advanced architectures. Recent software reliability research has indicated a potential fallacy in classical software reliability assumptions which could have a significant effect on the use of N-version software as a means for achieving extremely reliable systems. Increased emphasis will be applied to develop a credible software reliability model based on validated assumptions. In the advanced architecture area, the proof-of-concept hardware and software of the advanced information processing system, a distributed fault-and damage-tolerant architecture designed for real-time aerospace applications, will be tested to assess its ability to achieve high levels of function reliability, through graded redundancy and software function migration, and its capability for graceful degradation in the presence of faults.

Controls and guidance research directed at subsonic transports includes advanced transport operating systems, highly reliable digital control system architectures, and safety. The major focus in advanced transport operating systems will be four-dimensional (4-D) flight management system equipped aircraft integration with the air traffic control system. Research will establish preliminary algorithms needed to allow a transport to automatically fly the optimized trajectory from cruise to the terminal area metering fix, flight crew interfaces, and ground controller procedures to intermix 4-D and non-4-D equipped aircraft. This research will be performed in close coordination with the FAA, as will the research on airborne systems for the detection and avoidance of wind-shear safety hazards.

Rotorcraft controls and guidance research involves the application of artificial intelligence and expert systems technology to the difficult military rotorcraft mission of all-weather nap-of-the-earth (NOE) operations. The objective of this research is to develop flight path management and planning concepts for terrain following/terrain avoidance and manually controlled helicopter flight, leading to automated flight with assumed sensor-derived data. A rule-based expert system will be developed for invoking on-board mission replanning during NOE flight, and pilot/system interface concepts will be formulated. This research will be performed in cooperation with the U.S. Army.

Controls and guidance research directed at fighter/attack aircraft applications will stress the efforts underway on integrated airframe/propulsion control system architectures and multidisciplinary dynamics integration and will be expanded to include supermaneuverability considerations. Reconfigurable/restructurable control system concepts and artificial intelligence/expert systems technology will be investigated as potential solutions to the critical problem of transient thrust loss during propulsive control supermaneuvering flight.

Hypersonic vehicle guidance and controls research will explore new and unconventional guidance and outer-loop control modes for flight path control to achieve optimum performance and efficiency. In addition, concepts to integrate aerodynamic and propulsion controls for hypersonic cruise vehicles will be formulated.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Human factors research and technology..	20,300	22,000	22,000	24,000

OBJECTIVES AND STATUS

The objective of the human factors research and technology program is to provide the capability to design crew interfaces with new cockpit technologies (e.g., expert systems, voice interaction, flat-panel and virtual-image displays) which will permit maximum advantage to be taken of the potential of these technologies to enable increased capability, efficiency and safety in rotorcraft, air carrier, and general aviation. This is accomplished by developing an understanding of crew capabilities, limitations, and tendencies in interacting with these systems and delineating guidelines for implementing that understanding. There are four areas of emphasis in the human factors program: (1) flight management, (2) human engineering methods, (3) rotorcraft, and (4) subsonic transport/commuter/general aviation.

The flight management research program has continued to focus on crew interaction with cockpit automation and advanced information input/output methods. Having developed an expert system for fault monitoring and diagnosis of electrical systems, expert systems are under development for hydraulic and propulsion systems, so that crew capability to perform supervisory control functions over multiple expert systems can be evaluated. Another expert system has been developed for designing and selecting type fonts and symbols for electronic displays. A rule-based system has been initiated which will aid in the design of electronic display formats by providing an interactive data base on what is known in that area. Techniques have been developed for designing flight computer data bases consistent with how pilots organize the relevant data and for measuring the consistency of crew-computer interaction protocols in various computer modes.

Human engineering methods are focused on developing techniques for design and evaluation of cockpit equipment and operations. Current work is in workload measurement and simulation technology. A new model was developed for constructing simulator scenarios with predicted workload levels. This will enable increased flexibility in evaluating alternative cockpit technologies. In simulation technology, a methodology has been developed to optimize simulator motion systems by predicting the effect of motion washout algorithms on crews.

In the rotorcraft area, the focus is on providing the technology for single pilot capability in poor visibility for both military and civilian missions. A wide field-of-view head-up display is being developed. In addition, workload measures are being developed to assess the effects of potential cockpit improvements.

In the subsonic transport/commuter/general aviation area, the focus was on jet lag in air transport crews and on the potential use of data-link by general aviation pilots in instrument flight rules. Management of the aviation safety reporting system (ASRS) for the FAA has continued. Also, a high-resolution, 2-D model of wind shear was developed using computational fluid dynamics to simulate actual wind-shear conditions. Simulations of the Dallas-Fort Worth wind-shear accident were provided to the National Transportation Safety Board (NTSB). The man-vehicle system research facility, a high-fidelity simulation facility with a B-727 cockpit and an advanced concepts cockpit, became fully operational and was used for evaluation of sidearm contollers and wind-shear simulation models.

BASIS FOR FY 1987 ESTIMATE

The focus of the FY 1987 human factors research and technology program will shift from air transport and generic research to rotorcraft and high-performance aircraft. The generic human/automation interface research will be focused on problems associated with these specific classes of aircraft. The rotorcraft program will develop voice interaction capability, automated crew aids, and innovative information management concepts to enable night NOE flight and increased capability for commercial operations in foul weather. This will include the development of methods to evaluate alternative cockpit designs. Rotorcraft human factors research will utilize the Cobra surrogate trainer pilot night vision system facility. Previous accomplishments in automation interface and workload analysis will be applied specifically to rotorcraft cockpit design. Of particular importance will be the further development of techniques for consistent pilot-matched system interactions and reliable measures of automation-induced cognitive workload. Continuing studies of vestibular models for simulator motion systems will be especially important for accurate and cost-effective NOE rotorcraft simulation. The high-performance human factors research will focus on developing "electronic copilot" features for crew control of emerging artificial intelligence capabilities such as the automated wingman concept. It will also begin exploring the crew-related aspects of hypersonic/transatmospheric vehicles. Continuing expert system interface studies will offer increasingly quantified insight into pilot/automation interaction issues so that verified methods and models are available to guide hardware and software designers. This work benefits from a high degree of synergism with the space human factors program. In air transport, the jet lag program will be completed; management of the ASRS will continue; and guidelines will be developed for crew monitoring and control of multiple integrated expert systems. The manned vehicle systems research facility (MVSRF) will be used in support of the FAA for evaluation of threat alert and collision avoidance system displays. It will also be used for high-fidelity full-mission evaluation of human/automation interaction design guidelines. The ASRS data base of aviation incidents will be especially useful for identifying the most significant system and crew factors which require experimental investigation. It is expected that the extensive data on automation-induced incidents will be particularly important for guiding research in the advanced technology cockpit of the MVSRF.

	1985 Actual	1986 Budget Estimate	 Current Estimate	1987 Budget Estimate
		(Thousands of	Dollars)	
Flight systems research and technology...	17,864	18,300	18,300	21,500

OBJECTIVES AND STATUS

The objective of the flight systems research and technology program is to provide the necessary research and technology development for an improved and validated base of advanced technology for application by industry to future generations of the entire spectrum of aircraft. In many cases, joint funding is provided by NASA, DOD, and FAA. The program is organized into the following main categories: (1) aviation safety, (2) convertible engine rotorcraft propulsion, (3) high-performance aircraft, and (4) flight support. The activities within this program encompass advanced engineering techniques and the establishment of the feasibility of concepts to ensure rapid application of promising new technology essential to meeting one or more of the following goals: (1) reducing aircraft accidents resulting from weather effects (heavy rain, wind shear, lightning, turbulence, and icing); (2) developing convertible engine propulsion concepts which provide both thrust and shaft power that will enable military aircraft to retain the low-speed advantages of helicopters while allowing highly maneuverable high-speed flight; and (3) establishing a technology base for the design of future fighter aircraft with unprecedented maneuverability at high angle-of-attack (up to 90 degrees) flight conditions.

The objectives of the activities in aviation safety are to provide a better understanding of aeronautical safety hazards and their consequences and to provide criteria for design of aircraft systems and operating techniques. They involve the development of analytical models to predict ice accretion and its effects on aircraft handling qualities and airfoil performance for both rotary- and fixed-wing aircraft, development of ice protection systems, establishment of a flight-validated lightning strike data base for development of design criteria for advanced materials and digital avionics systems, and the quantification of the effects of heavy rain on aircraft aerodynamic and propulsion system performance. NASA has completed the technology development of an electro-impulse deicer concept, reported the results in an industry symposium, and assisted the Army in resolving the A-10 inlet icing problem. The instrumented F-106 severe storms research aircraft is completing the characterization of direct lightning strikes to the aircraft in convective weather. The resulting first-of-a-kind data base is providing the basis for the development of threat models for use by FAA and industry for materials and avionics protection. Wind tunnel investigations of heavy rain effects are providing an initial data base for modeling the resulting degradation of aircraft performance.

The objectives of the convertible engine rotorcraft propulsion technology program are to provide technology readiness in experimental propulsion systems for rotorcraft and V/STOL aircraft incorporating advanced convertible engine concepts providing both shaft and thrust power requirements. The steady state power modes have been demonstrated, and the crucial transient conversion requirement for application to compound configurations, such as the X-wing, has been successfully accomplished. The convertible engine concept will provide designers of future rotorcraft and V/STOL aircraft a new dimension with a single powerplant capable of providing turboshaft power and turbofan thrust power simultaneously or individually. This program will be completed in 1986.

The objectives of the high-performance aircraft program are to refine and validate aerodynamic predictive tools at high angle-of-attack flight conditions, and to demonstrate the performance benefits and utility of propulsive flight control. Negotiations have also been conducted with the United Kingdom for cooperative investigations of several design concepts for a supersonic advanced short takeoff and vertical landing (ASTOVL) aircraft capability.

The objectives of the flight support program are to provide a variety of support services to flight research projects using standard aircraft for chase, airspeed calibration, remotely piloted research vehicle air drops, and flight crew readiness training. Replacement of the Ames-Dryden aging F-104 high-performance support aircraft with Navy-loaned full-scale development F-18 aircraft has been initiated.

CHANGES FROM FY 1986 ESTIMATE

The total for this program has not changed. A decrease to support hypersonics technology ($0.6 million) and systems analysis studies ($0.4 million) has been restored with the application of $1.0 million from the oblique wing systems technology program.

BASIS OF FY 1987 ESTIMATE

In FY 1987, the aviation safety program will emphasize coordinated wind tunnel, analytical, and flight research investigations and analyses leading to an understanding of ice accretion and its effects on fixed- and rotary-wing aircraft performance and handling qualities. Research to establish a flight-validated severe storms/lightning effects data base will be completed and the results reported to the FAA and industry. Wind tunnel and analytical investigations will be continued to establish a data base for analysis and understanding of the effects of heavy rain on aircraft aerodynamic and propulsion system performance.

The high-performance aircraft program will continue in FY 1987. Wind tunnel and analytical research will be conducted to investigate the potential benefits and aerodynamic, propulsion system, and structural interactions resulting from multiaxis thrust vectoring at high angle of attack. Simulator and design studies will be completed to establish a data base for the potential integration of aerodynamic and propulsive flight controls on the NASA F-18 high alpha research vehicle. Wind tunnel research will be completed to support the flight validation of the aerodynamic performance benefits of a leading-edge vortex flap for enhanced maneuvering performance. In the U.S./U.K. ASTOVL program, propulsion system and airframe design studies will be conducted to identify the advantages and disadvantages of alternative propulsion system concepts for a supersonic V/STOL aircraft. The study results will be used to guide the research activities required to develop the technology base for the most promising aircraft/propulsion system concepts.

Flight test support of flight research projects will continue using a variety of both fixed- and rotary-wing aircraft. In the main, these standard aircraft will be flown as chase aircraft in support of research helicopters and aircraft described under high-performance aircraft systems technology (X-29A, F-15, F-18, YAV-8B). The test support activity also provides for flight crew training, maintenance of flight data facilities, aircraft instrumentation, and flight data processing.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Systems analysis......................	2,600	3,200	4,000	4,800

OBJECTIVES AND STATUS

The objective of the systems analysis effort is to examine the technology needs and opportunities for future vehicle concepts and to provide performance data and sensitivity analysis for effective long-range planning. The studies identify high-payoff, emerging technologies that can lead to new plateaus or major improvements in civil or military vehicle performance, creation of new markets, and potential economic benefits. The following vehicle classes are addressed by the studies: subsonic, rotorcraft, supersonic cruise, high performance, and hypersonic for a variety of civil and military applications.

The systems analysis studies for the subsonic aircraft, which include general aviation, commuter, and transport aircraft, concentrated on the benefits associated with laminar flow and advanced turboprop concepts in FY 1986. The studies addressed the economics of commuter aircraft and small subsonic advanced propfan transports utilizing advanced technologies. Studies were conducted to assess the impact of very advanced materials and structures for subsonic transport applications.

The study efforts for sustained supersonic cruise technology are examining innovative configurations incorporating advances in aerodynamics and propulsion system technologies for advanced military and civil aircraft and the payoff of efficient, economical, advanced processing methods that exploit the full weight-savings potential of advanced metals. Supersonic throughflow fan engine concepts are also being examined.

An ongoing study effort is assessing the benefits of new emerging technologies to the fighter/attack class of aircraft. Also, as part of a cooperative U.S./U.K. ASTOVL program, multidisciplinary analysis and design studies are exploring concepts that utilize high thrust-to-weight engines and thrust-vectoring control. The conceptual studies will form the basis for selection of the most promising concepts for technology development.

Studies in FY 1986 for hypersonic vehicles concentrated on performance and weight estimates associated with turboramjet, ejector ramjet, and air-turboramjet concepts. Studies have been initiated to assess unique far-term hypersonic propulsion concepts.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The increase of $0.8 million in systems analysis reflects increased emphasis on study activities primarily directed toward high-speed and hypersonic propulsion technology.

BASIS FOR FY 1987 ESTIMATE

In FY 1987, studies will investigate the benefits of emerging small-engine technologies for applicability to general aviation and commuter aircraft. Rotorcraft systems analysis will be assessing the potential impact on civil transportation opened by the high-speed tilt rotor and X-wing concepts. These concepts have tremendous potential for both the civil and military markets, especially as emerging new technologies, such as convertible engines and folded or stowed rotors, are developed.

The studies for sustained supersonic cruise in FY 1987 will focus on defining the technology requirements and vehicle characteristics necessary to meet projected opportunities and requirements. Technologies will be identified and assessed for long-range, economically viable high-speed aircraft with particular emphasis on aerodynamic, structural, and propulsion concepts for speeds ranging from Mach 2.5 to 5.0.

Technology integration studies for advanced fighter concepts will focus on new capabilities enabled by key emerging technologies. Thrust-to-weight ratio of fighter engines is expected to double over the next decade. Combined with advances in lightweight materials and structures, this could result in small lightweight fighters with high overall thrust-to-weight ratio. Configurations will be assessed that vector and/or deflect the thrust for control augmentation and direct lift generation.

In terms of our military posture, hypersonic speed and high-altitude performance characteristics in both airplanes and missiles have obvious advantages for national defense as well as for hypersonic transports, which could cut the trip time in half relative to a Mach 2 or 3 transport. Aircraft productivity will be improved with increasing Mach number. Vehicle design matrices incorporating projected technology advances are required to determine the performance potential and technology needs. Prospective vehicles and their mission capabilities will be assessed along with their sensitivity to technology options. These formulations will employ the synergistic integration of aerodynamic, aerothermal, propulsion, structural, and controls technologies with emphasis on propulsion options and will be used to guide NASA's technology development in this important area.

BASIS OF FY 1987 FUNDING REQUIREMENTS

SYSTEMS TECHNOLOGY PROGRAMS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Rotorcraft systems technology.........	26,000	20,500	20,500	18,700	RD 13-39
High-performance aircraft systems technology..........................	21,530	21,800	20,800	26,000	RD 13-41
Subsonic aircraft systems technology..	19,000	---	---	---	
Advanced propulsion systems technology	26,100	44,200	44,200	28,400	RD 13-45
Numerical aerodynamic simulation......	26,472	28,200	28,200	30,000	RD 13-47
Total..............................	119,102	114,700	113,700	103,100	

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Rotorcraft systems technology				
Advanced rotorcraft technology......	9,632	2,700	2,700	2,000
Technology for next generation rotorcraft........................	16,368	17,800	17,800	16,700
Total................................	26,000	20,500	20,500	18,700

OBJECTIVES AND STATUS

The rotorcraft systems technology program conducts research on two fronts. The first thrust consists of efforts in the broad systems technology areas of comprehensive noise prediction and full-scale wind tunnel tests. The goal of this thrust is to predict overall vehicle noise to ±1.5 decibels accuracy and to acquire airloads for new design techniques for "jet-smooth" vibration. The second thrust involves the X-wing rotor demonstration test on the rotor systems research aircraft (RSRA).

In the noise program conducted with the American Helicopter Society (AHS), an updated, comprehensive noise prediction code was released to industry. Accuracy is expected to be ±3 decibels in most cases for existing designs. Also, the first prediction of blade-vortex interaction noise was made using new analytical tools. A full-scale flight test of a Hughes 500 helicopter, with engine noise muffled, was initiated to determine the contribution of individual sources to varying noise levels due to turbulence and wind.

In full-scale testing, an Army LHX main rotor was tested in the newly upgraded 40x80-foot wind tunnel. The first full-scale test of main rotor/tail rotor aerodynamic interference was also run in the 40x80-foot wind tunnel. Acquisition of a pressure-tapped main rotor and a hingeless rotor will be started for an FY 1987 tunnel entry to investigate high-speed airloads and rotor-dynamic stability. These data previously did not exist for correlation for noise and vibration prediction/reduction.

In the joint DARPA/NASA RSRA/X-wing rotor investigation, the prime objective is to perform an X-wing conversion from rotary to stopped-rotor flight and return to rotary-wing flight. The flight research program will also investigate the dynamic stability, performance, and rotor control characteristics of the X-wing rotor system. Completed to date are the RSRA airframe modification; the propulsion and pneumatic system; the propulsion system testbed (PSTB) facility; an integrated, mobile data acquisition facility; a prototype, digital fly-by-wire flight control computer; and high-temperature composite rotor blade components. Testing has been initiated in the PSTB, wind tunnel, and flight control computer laboratory.

In 1986 the fabrication and assembly of the X-wing rotor system will be completed, and the rotor system will be installed on the PSTB and subsequently on the aircraft. Preceding flight, the X-wing rotor system will be extensively tested on the PSTB, an "iron bird" ground-based facility, and the reliability of the flight control system will be extensively tested in the vehicle management system laboratory which was specifically developed to test the unique X-wing flight control system. Supporting research includes upgraded piloted simulations in the Ames Research Center's vertical motion simulator and upgraded scale-model wind tunnel tests. These tests will concentrate on the flight mode in which the aircraft "converts" from rotary to stopped-rotor at speeds near 200 knots.

BASIS OF FY 1987 ESTIMATE

The NASA/AHS program will continue with the release of new subroutines for rotor loads and rotor wakes. Blade vortex interaction noise will be emphasized to determine the benefits of airfoil nose shape using more powerful 3-D predictions. Aerodynamic interference will also be incorporated in the comprehensive prediction code. Prediction accuracy is expected to approach ±1.5 decibels for takeoff and flyover conditions for existing designs. Advanced designs and landing conditions will await better analysis.

In FY 1987 the X-wing flight test program is planned to be completed. The program will also be generating ground-based piloted simulation PSTB data, and vehicle management systems data in support of the flight investigation of the X-wing rotor on the RSRA. This fast-paced, advanced technology program will require extensive, coordinated testing in 1987 which is crucial to the success of the flight investigation and will require special NASA capabilities to support the contractor's efforts. In particular, the flight testing will culminate in the historic demonstration of conversion from rotary to stopped-rotor flight for cruise and a reconversion to rotary flight for landing.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
High-performance aircraft systems technology				
High-performance flight research....	9,730	9,800	9,800	10,400
Turbine engine hot section technology..........................	9,300	5,200	5,200	5,000
Ceramics for turbine engines........	2,500	2,100	2,100	2,200
Oblique wing technology.............	---	4,700	3,700	8,400
Total...............................	21,530	21,800	20,800	26,000

OBJECTIVES AND STATUS

The objective of the high-performance aircraft systems technology program is to generate validated engineering methods and design data applicable to the development of advanced high-performance, high-speed aircraft applications. The program objectives are accomplished by analysis, ground-based simulations, wind tunnel experimental research, and flight research tests of advanced aircraft concepts and systems.

In the joint NASA/Air Force advanced fighter technology integration (AFTI) program, the AFTI/F-16 automated maneuvering attack system flight phase is being completed. The AFTI/F-111 mission adaptive wing project will complete the flight research activity to validate predicted performance improvements, including range increase of 25 percent, resulting from its variable camber airfoil. In the F-15 highly integrated digital electronic control (HIDEC) program, which builds on the capability developed during the digital electronic engine control and F-100 engine model derivative programs, flight research testing has begun to validate 10- to 15-percent aircraft performance improvements through integrated digital electronic controls. In the NASA/DARPA X-29A forward-swept wing flight demonstration program, the aircraft will complete the baseline flight program in 1986 to validate predictive tools and exploit the advanced technologies designed into the experimental aircraft. The F-18 high angle-of-attack flight testing will begin in the third quarter of FY 1986 on an unmodified F-18. The goal of the program is a flight-validated data base for design of highly maneuverable aircraft with a 90-degree angle-of-attack capability. Initial flight tests will focus on the development of a flight-validated aerodynamic data base for correlation with wind tunnel and analytical predictions. Design studies and wind tunnel testing are leading to the modification of an F-106 aircraft to validate the predicted improvements on aircraft takeoff, landing, and maneuver flight performance resulting from use of vortex flap technology. Flight testing of a YAV-8B Harrier is continuing for validation of wind tunnel, analytical, and simulator predictions of V/STOL aircraft characteristics.

During FY 1986 the turbine engine hot section technology (HOST) program continues to address the issues involved in engine durability. The objectives are to establish predictive methods for the structural response and life of hot section components by developing analysis methods, instrumentation and verification test methodology. During this year the new high-temperature structures and fatigue laboratory at Lewis Research Center began operation. This unique national facility allows for the study of the behavior of turbine blade and burner liner materials under realistic, complex, thermomechanical loading conditions. Improved numerical schemes for 3-D aerothermal flow interaction with combustor liners have been developed and benchmark experimental tests conducted. Progress on the development of specialized 3-D nonlinear analysis methodology to predict component response and life has been substantial. Constitutive laws have been developed which actually predict single crystal blade response. The ability to predict coolant passage heat transfer during blade rotation has been achieved, greatly increasing our understanding of cooling effects. Improved theories of salt deposition on rotating airfoils have been developed, leading to better models for coating performance in corrosive turbine environments.

As part of the activity to develop higher performance longer life turbine blade materials, the ceramic research program has continued to make progress in FY 1986. Critical processing variables in the preparation of silicon-nitride and silicon-carbide powders have been determined. Hot isostatic pressing of sintered ceramic bodies has shown a 100-percent improvement in flaw reduction. A new nondestructive evaluation approach, laser-acoustic microscopy, has demonstrated the ability to accurately find 50-micron surface flaws in silicon nitride. In this year an advanced brittle design code, developed in-house at Lewis Research Center using Batdorf statistics, has demonstrated greater accuracy in describing ceramic material failure response. This code has been released to industry and is seen as a major advance. Initial studies on the application of ceramic composites for turbine blades have shown promise for the development of "tough" ceramics.

The objective of the joint NASA/Navy oblique wing program is to establish a flight-validated data base for application of the technology to future civil and military aircraft. For over forty years NASA has investigated oblique wing technology, including wind tunnel tests, simulations, aircraft design studies, and low-speed manned and unmanned flight tests. These studies have indicated significant performance advantages for an oblique wing aircraft, as compared to a conventional swept wing, for missions requiring both efficient subsonic cruise and supersonic dash performance. In addition, the concept offers significant improvement in aircraft carrier airplane spotting ratios for Navy flight deck operations.

The oblique wing technology development will be completed by the design, construction, and flight evaluation of an aeroelastically tailored composite oblique wing at transonic and supersonic speeds. The NASA F-8 digital fly-by-wire (DFBW) test aircraft will be utilized as the research testbed for the flight program. This aircraft provides for easy installation of the oblique wing, as well as a well defined, readily modifiable, highly flexible, digital flight control system. A wing preliminary design contract has been awarded and will provide the basis for the final design and initiation of the fabrication of the wing, pivot mechanism and required modifications to the F-8 DFBW testbed. This activity will lead to the start of the flight test program in 1989.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The reduction of $1.0 million in high performance aircraft systems technology reflects a reduction in the oblique wing technology program in accordance with Congressional direction. This funding has been redirected to cover high priority requirements in the flight systems research and technology base program.

BASIS OF FY 1987 ESTIMATE

The flight research activity in FY 1987 will involve a variety of high-performance aircraft to investigate advanced concepts. Several projects will continue their flight phases during this period. The F-15 HIDEC will complete flight test validation of performance improvements resulting from propulsion system variable operating line control. The NASA/DARPA X-29A aircraft program will be expanded to include Air Force participation in a follow-on flight research program on the first aircraft within the established envelope (angle of attack less than 20 degrees). The second X-29A aircraft will be modified to include a spin chute to enable flight research testing of the forward-swept wing technologies above 20 degrees angle of attack. The F-106 aircraft will conduct flight tests of the vortex flap concept for correlation with wind tunnel and analytical predictions. The F-18 high angle-of-attack testing will continue. Included will be measurements of forebody aerodynamics with vortex interactions and correlation with wind tunnel and analytical predictions. The YAV-8B Harrier flight test program will complete the baseline aerodynamic and engine bleed flow experiments and initiate flight investigations to support supersonic STOVL aircraft concept design studies.

During FY 1987, the turbine engine hot section technology program will continue to concentrate on developing improvements in high-temperature instrumentation, methods for structural analysis, aerothermomechanical environment modeling, and life prediction. Research will continue on the development of an accurate model for dilution jet effects on combustor flow. Additionally, an improved laser anemometer system for the measurement of high-temperature flow in the combustor will be completed. Heat transfer research will concentrate on developing an advanced turbine airfoil turbulent flow model, including rotor-stator interaction. Once developed, the more accurate heat loads can be applied to predict the airfoil structural response characteristics. Studies of the nonlinear 3-D response of combustor components under high heat gradients will continue. Time-dependent crack propagation prediction methodologies will be emphasized leading to a greatly improved life prediction ability of liners, vanes, and blades.

The research on monolithic silicon-nitride and silicon-carbide ceramics will continue to develop improved understanding of the processing steps necessary to achieve highly reliable turbine blades. The corrosion response of ceramic in the aggressive gas turbine engine environment will be modeled. This next year will see increasing emphasis on ceramic matrix materials. Processing variables for silicon carbide with embedded continuous ceramic fibers will be a major focus. Related deformation and fracture mechanics will be studied and initial constitutive analysis begun. Nondestructive evaluation techniques will be continued with emphasis on near surface flow detection.

In 1987 the contract for final design, fabrication, and ground qualification testing of the oblique wing and F-8 DFBW aircraft system interfaces/modifications will be awarded. In-house NASA/Navy wing aerodynamic design and direct project support research and technology activities will be continued. The in-house program will include wind tunnel investigations, simulations, and the application of advanced aerodynamic and structural analysis computer codes.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Advanced propulsion systems technology				
Advanced turboprop systems..........	24,000	42,000	42,000	26,000
General aviation/commuter engine....	2,100	2,200	2,200	2.400
Total..............................	26,100	44,200	44,200	28,400

OBJECTIVES AND STATUS

The objective of the advanced propulsion systems technology program is to explore and exploit advanced technology concepts for future aircraft propulsion systems in high-payoff areas through the focusing of fundamental research and technology efforts and integration of advanced propulsion components.

Activities in the advanced turboprop systems program are devoted to establishing concept feasibility and providing the broad research and technology data base necessary for achieving the concept's full potential. Information on aerodynamic performance, aeroelastic stability, and acoustic environment will be obtained for the data base and used partially to support flight test programs for verification and for obtaining data under actual flight conditions. The 9-foot-diameter large-scale advanced propeller (LAP), to be used during flight tests, and the 2-foot-diameter aeroelastic model of the LAP have been fabricated. Wind tunnel tests of the aeroelastic model confirmed stability up to a Mach number of 0.85, the highest planned during flight testing. The LAP was static ground tested at the Wright-Patterson Air Force Base for takeoff performance, blade stress levels, and stall flutter, and all were found to be as predicted. During FY 1986 the LAP will be tested in a high-speed wind tunnel for performance and flutter boundaries. One-ninth scale model tests of the propeller test assessment flight test aircraft with the turboprop installed have provided flutter and high-speed drag characteristics. In 1986 the aircraft model will be used to determine low speed stability and control characteristics, and a ground test will be performed on the LAP mated with the flight gearbox and turboprop power section. Ground tests of the General Electric unducted fan engine, a gearless counter-rotation propfan concept, were initiated in September 1985 and will be completed in March 1986. Initial results show propulsion and aeroelastic performance as predicted, as well as good propeller speed control. Propeller/wing installed aerodynamic data for analytical code verification was obtained in a wind tunnel investigation. To develop a firm understanding of how propeller parameters, such as sweep and spacing, affect acoutics, a parameteric study is being conducted with 2-

foot-diameter geared and gearless counter-rotation propellers. These tests show that good performance can be maintained at reduced noise levels.

In the general aviation/commuter engine systems technology program, aimed at raising the performance level of small turbine engines to more proportionately match that of large engines, work is focused on providing fundamental measurements to lead to a detailed understanding of how improvements can be made. The multistage compressor facility was used to obtain fundamental data such as velocities, pressures, and surge margin for verification of 3-D analytical codes. Turbine blading was installed in the new experimental facility for determining loss mechanisms in small turbines. Tests were continued to prove centrifugal compressor scaling laws and will be completed in FY 1986. In the joint NASA/Air Force program for cruise missile technology, the combustor was assembled for experiments to evaluate temperature profiles. Small engine systems studies to identify efficient cycles and high-yield technology areas were completed and will provide the foundation for a long-range plan for advanced small turbine engines.

BASIS OF FY 1987 ESTIMATE

In FY 1987 advanced turboprop systems research will emphasize the flight test of the LAP in a propeller test assembly for concept verification and broadening of the data base to flight conditions and supporting technology for cabin acoustics and turboprop/airframe installation aerodynamics. The LAP, nacelle, and turboprop power section will be installed on a modified Gulfstream II aircraft for flight testing in FY 1987. The flight tests will evaluate large-scale structures, aeroelastics, propeller source noise, and untreated cabin environment at a variety of flight conditions up to a Mach number of 0.85 and an altitude of 35,000 feet. More fundamentally, cabin acoustics research is being performed and will include development of analytical techniques to predict cabin environment for various inputs of propeller source noise and cabin treatment concepts that have the potential to achieve attenuation levels required for high-speed propellers. Installation aerodynamics research will include analytical and experimental technology development to determine high-speed performance and low-speed stability and control for configurations of practical interest not yet studied in detail, including wing- and aft-mounted, single- and counter-rotation concepts.

The general aviation/commuter engine technology effort will continue to focus on developing fundamental understanding and obtaining an analytical and experimental data base for use in future advanced small engines. Fabrication of the large low-speed centrifugal compressor, to be used for definition of the flow field, will be completed. Combustor pattern factor studies to understand how to improve the temperature profile for longer turbine blade life will be undertaken, and laser measurements to aid in understanding loss mechanisms in turbine flow fields will be made. Regenerator/recuperator heat transfer studies will be started. Based on the small engine systems studies, an overall technology development plan will be developed.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Numerical aerodynamic simulation......	26,472	28,200	28,200	30,000

OBJECTIVES AND STATUS:

The numerical aerodynamic simulation (NAS) program objective is to significantly augment the nation's capabilities in computational fluid dynamics and other areas of computational physics by developing a preeminent capability for numerical simulation of aerodynamic flows. This program will provide the computational capabilities required to obtain solutions to problems which are currently intractable. Ongoing research and technology base efforts in computational aerodynamics will benefit significantly from the advanced computational capabilities to be provided by the NAS program. The combination of these programs will provide pathfinding aeronautical research for the future, allowing solutions of the full Navier-Stokes equations, providing first-principle prediction of viscous flow about simple aeronautical shapes, and enabling the prediction of performance of complete aircraft. The NAS program will develop an extensive user-friendly system to assist engineers and scientists in all aspects of problem solution, from problem formulation through graphical presentation of results. The heart of this system is the high-speed processors, which will be upgraded when new supercomputer systems, at least four to six times more powerful than existing machines, become available. These machines will provide the large-capacity/high-speed computational capability required in advanced fluid dynamic research and applications.

The NAS program study and planning phase was initiated in the research and technology base in FY 1983, with system development beginning in FY 1984. The system design review was held in FY 1984 and formalized the design of the NAS system. The system software development contractor began development of the network language and protocols during FY 1984. Major hardware procurements were initiated in FY 1984, leading to assembly of the initial operating configuration during FY 1985. Full-scale development of the NAS network hardware began with the delivery of the integrated support processor complex (front-end computers and supporting equipment) in mid-FY 1985. The first high-speed processor, a Cray 2 supercomputer, was delivered late in FY 1985 and integration into the NAS network begun. The first part of FY 1986 is an intense test and integration period leading to operational status of the NAS initial operating configuration (IOC) during the third quarter of FY 1986. During FY 1986 construction will be completed for the NAS facility.

BASIS OF FY 1987 ESTIMATE

FY 1987 will be the key year in the development of the NAS system. The NAS building will be occupied and the second high-speed processor (HSP-2), which will be four to six times more powerful than HSP-1, will be installed. Secure (classified) processing will be initiated with the move into the new building. During FY 1987 the IOC, built around HSP-1, will be used to obtain the first solution for subsonic and transonic viscous flow about complete aircraft configurations. It will also be used to provide pathfinding viscous flow solutions to supersonic/hypersonic airframe/propulsion integration for advanced configurations being studied in the national aerospace plane program and to obtain complete flow field solutions for complex nonequilibrium, chemically reacting, and radiating flows about candidate aeroassisted orbital transfer vehicles. The acquisition and installation of the HSP-2, which constitutes the NAS extended operating configuration (EOC), will complete the initial planned architecture of the NAS system. It will serve as the foundation for the upgrading of the major subsystems in the building toward the EOC. The mass storage subsystem will be expanded to handle the additional archival storage required for support of the HSP-2. The graphics subsystem development will be accelerated to accommodate both high-speed processors. During this period, system software development will continue, and all new components will undergo extensive test and integration.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY **TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY**

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Transatmospheric research and technology	---	---	---	45,000	RD 14-2

Distribution of Program Amount by Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Ames Research Center....................	---	---	---	6,250
Langley Research Center.................	---	---	---	23,000
Lewis Research..........................	---	---	---	15,750
Total................................	---	---	---	45,000

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OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY **TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY**

PROGRAM OBJECTIVES AND JUSTIFICATION

NASA, in conjunction with the Department of Defense, is developing the technology base for a potential national aerospace plane. The objective of the NASA transatmospheric research and technology program is to accelerate the development of the critical enabling technologies for a potential revolutionary new class of hypersonic/transatmospheric vehicle in the future. Such a vehicle could be capable of horizontally taking off from and landing on conventional runways, using airbreathing propulsion up to, or near, orbital speed, and providing rapid and low-cost access to space. This augmentation of previous NASA in-house research and technology base efforts would accelerate the development and validation of key technologies through fabrication of components and subsystems by testing in ground-based facilities and small-scale flight experiments. The critical technologies include efficient airbreathing propulsion with emphasis on scramjet techniques that provide net thrust from takeoff to near orbital speeds; reusable thermal structures that can withstand repeated combinations of extreme peak heating and long-duration heat loads; and complete integration of the propulsion system with the airframe for a minimum weight system with good performance throughout a broad range of acceleration, cruise, and maneuvering flight conditions. A necessary precursor to possible future year decisions on a demonstrator research aircraft program, these validated technologies could form the critical data base required for design and integration of complex propulsion and structural systems into a vehicle configuration capable of transatmospheric flight.

This program is an outgrowth of the ongoing aeronautics and space research and technology programs. It is a multicenter program (Ames, Langley, and Lewis) directed at generating the technologies required to provide the variety of options afforded by airbreathing transatmospheric vehicles. The opportunities for exploiting this regime for advancement of national interests are broadly recognized -- including launch vehicles, hypersonic transports, and military applications.

BASIS FOR FY 1987 ESTIMATE

Supporting activities ongoing in the NASA research and technology base include research in airbreathing hydrogen-fueled scramjet propulsion technology, advanced high-temperature materials and thermal structural concepts, and computational fluid dynamics -- the three critical technologies for transatmospheric vehicle applications. The FY 1987 program will focus on development of analysis and prediction techniques and validation of the performance for airbreathing propulsion concepts, actively cooled high-temperature structures, cryogenic insulated tankage, configuration aerodynamics, and propulsion system/aircraft integration characteristics.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY — **SPACE RESEARCH AND TECHNOLOGY PROGRAM**

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Research and technology base..........	136,358	140,000	132,800	133,600	RD 15-5
Systems technology programs...........	8,742	20,000	27,200	37,400	RD 15-35
Standards and practices...............	4,900	8,000	8,000	9,200	RD 15-46
Total..............................	150,000	168,000	168,000	180,200	

Distribution of Program Amount by Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Johnson Space Center..................	12,947	11,600	10,600	10,800
Kennedy Space Center..................	396	600	400	100
Marshall Space Flight Center..........	14,162	20,200	17,800	19,400
Goddard Space Flight Center...........	6,492	6,600	6,700	7,000
Jet Propulsion Laboratory.............	24,983	23,400	23,700	27,900
Ames Research Center..................	15,770	15,300	16,200	18,900
Langley Research Center...............	37,953	45,000	46,100	48,400
Lewis Research Center.................	30,524	37,800	37,300	37,900
Headquarters..........................	6,773	7,500	9,200	9,800
Total..............................	150,000	168,000	168,000	180,200

PROGRAM OBJECTIVES AND JUSTIFICATION

The overall goal of the space research and technology program is to advance the technology base in support of NASA's role as an effective, productive, and long-term contributor to the continued preeminence of the United States in space. The specific objectives of this program are to: (1) support a broad-based advanced technology program designed to provide new concepts, materials, components, devices, software, and subsystems for use in United States space activities; (2) assure preeminent national capability through extensive participation in the program by the NASA centers, other government agencies, universities, and industrial research and technology organizations; and (3) support a strong institutional base to maintain NASA centers in positions of recognized excellence in critical space technologies. The space research and technology program is comprised of two major elements: (1) the research and technology base to support advanced disciplinary technologies that provide the necessary base of understanding to create new opportunities for future national, civil, military, and commercial space mission objectives; and (2) systems technology programs which extend research and technology base efforts by providing system-level and in-space experiment capabilities which permit the generation of data not possible in ground facilities and the in situ validation of advanced technology in support of its transfer into space projects.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The space research and technology program total remains unchanged from the FY 1986 budget estimate; however, within this program, realignments have been made to cover high priority requirements, as described in the individual program statements. In addition, the OTV technologies program ($3.0 million) has been transferred from systems technology to the space research and technology base, and the automation and robotics effort ($10.2 million), previously budgeted and managed in various programs within the space research and technology base, has been consolidated and established as a systems technology program beginning in FY 1986 for management focus.

BASIS OF FY 1987 ESTIMATE

The FY 1987 program in space research and technology will continue to be directed toward providing the broad base of innovative technology essential to the conduct of future space missions. As such, it supports agency goals in space transportation, space station, and space science and applications, as well as providing synergistic support to military and commercial space user needs.

In aerothermodynamics, continued program emphasis will be on developing analytical and predictive techniques for the transition regime and linking between continuum and rarefied flow regimes. Additional emphasis will be placed on investigating aerodynamic and aerothermodynamic performance of aeroassist orbit transfer vehicles (AOTV) and transatmospheric vehicles. The space energy conversion program will continue its emphasis on high-capacity power and thermal systems for evolutionary space station needs and on technology for high-specific power, low-weight systems for low-earth and geosynchronous orbits and planetary missions. Propulsion technology will be directed toward understanding performance and life parameters for advanced cryogenic engines, stressing component and integrated diagnostic instrumentation techniques; orbit transfer engine technology to enable development of space-based, throttleable, reusable systems; and technology for gaseous oxygen-hydrogen propellant systems for evolutionary growth station or OTV auxiliary propulsion needs. The electric propulsion effort will address auxiliary propulsion applications, with continuing attention on fundamental life and performance limiting mechanisms and thrusters. Materials and structures activities will continue with research in large-area space structures, emphasizing erectables and deployables, and analysis of dynamic response and controls interaction. The work on improved thermal protection systems and related thermal-structural analysis methodology for OTV aerobraking and other advanced transportation vehicle concepts will continue. The effects of the space environment, particularly atomic oxygen interaction on lightweight materials for spacecraft and platforms, will continue as a major thrust. In space data and communications, emphasis will be placed on advanced information processing, high-capacity, high data-rate storage systems to increase the capabilities of on-board data systems and advanced microwave and optical communications technology. The information sciences program will emphasize software technology, reliable computing, concurrent processing, radiation-tolerant electronics, and sensing technology for potential spacecraft and space station applications. Emphasis in the controls and guidance area will be placed on precise control of large, flexible space structures; the precision pointing of large spacecraft; and adaptive guidance concepts for future transportation systems. Human factors efforts are aimed at the enhancement of astronaut productivity through improved crew stations with "human engineered" information management techniques and extravehicular work stations.

Efforts in space flight research and technology will continue to be directed toward the orbiter experiments program, which will exploit the operational flights of shuttle to investigate the aerodynamic and aerothermodynamic phenomena of the current shuttle as a means of validating experimental and predictive techniques for the design and development of future space transportation systems; the design definition for the aeroassist flight experiment to provide the data base for future space-based orbital transfer vehicles; the cryogenic fluid management flight experiment to develop the technology base for space station operations and a space-based orbital transfer vehicle; the development of a shuttle common carrier for structure and control/structure interaction experiments (called STEP -- space technology experiments platform); and the in-space experiments program which will provide access to space on NASA vehicles for the conduct of user (industry and university) space experimentation. The systems analysis area will focus on the identification of requirements and high-leverage technologies for the development of future space missions, such as a priority earth-to-orbit transportation vehicle and the evolutionary space station. The analysis efforts provide scope and direction to the base research programs and identify system-level technology programs required to assure transition of identified technologies into flight programs.

In systems technology, the advanced earth-to-orbit technology program will focus on providing system-level data for modeling performance and life and on evaluating advanced technology components designed to improve life and reduce maintenance costs in advanced engines. The components will be installed on a testbed engine and instrumented to provide the overall understanding and data base on performance in the realistic hot-fired engine environment. This is a joint program in which the Office of Space Flight will provide a non-flight space shuttle main engine as the testbed engine. The control of flexible structures flight experiments address structural dynamics and controls issues which must be understood prior to the deployment of large space structures having precision control requirements. This program will focus on developing and validating analytical methods for predicting coupled structural dynamics and control response for multibody space structures. A flight test program will be conducted with a series of four or more shuttle sorties, building progressively from modeling and modal characterization of large space structures to more complex flexible-body interactive control issues. The first flight article, the mast flight system, will address beam dynamics and control and will be flown on the shuttle in FY 1989. The automation and robotics program will provide the fundamental technology for space telerobotics and system autonomy to enhance operational capability and decrease the cost of space operations.

BASIS OF FY 1987 FUNDING REQUIREMENTS

RESEARCH AND TECHNOLOGY BASE

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Aerothermodynamics research and technology..........................	10,100	10,600	10,800	11,200
Space energy conversion research and technology..........................	22,312	22,900	21,200	20,400
Propulsion research and technology....	20,500	20,900	22,300	21,000
Materials and structures research and technology..........................	18,800	19,300	18,600	18,900
Space data and communications research and technology......................	16,500	16,900	16,000	13,600
Information sciences research and technology..........................	17,590	18,000	9,900	10,200
Controls and guidance research and technology..........................	8,600	8,900	7,500	7,500
Human factors research and technology..........................	3,700	4,000	2,300	2,300
Space flight research and technology..........................	11,468	11,900	17,400	22,400
Systems analysis......................	6,788	6,600	6,800	6,100
Total..............................	136,358	140,000	132,800	133,600

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Aerothermodynamics research and technology........................	10,100	10,600	10,800	11,200

OBJECTIVES AND STATUS

Future aerospace vehicles, such as aeroassisted orbit transfer vehicles (AOTV), the aerospace plane, and the hypersonic cruise and maneuver vehicles, will have to be capable of sustained hypervelocity flight in rarefied atmospheres. The design of these vehicles presents some formidable performance prediction challenges. To meet these challenges, the aerothermodynamics program is pursuing the following objectives: (1) develop advanced numerical algorithms for continuum, transitional, and free molecular flow regimes; (2) develop accurate and detailed finite-rate chemistry and turbulent flow models; (3) correlate ground and flight (shuttle orbiter experiments) experimental data with calculations; (4) establish a detailed aerothermal loads data base and integrated analysis technique; and (5) provide a fully integrated design and analysis capability to support future vehicle/mission requirements.

Progress in the ability to predict flow fields about vehicles entering/maneuvering in the earth's atmosphere has been greatly accelerated by the rapid increase in computational capability in memory and speed, as well as efficient algorithm development. The predominant emphasis in continuum flow calculations has shifted from the inviscid (Euler) flows to the more realistic viscous shock layer methodology to the full Reynolds-averaged Navier-Stokes equations. One of the latest and most promising techniques is a thin-layer Navier-Stokes algorithm developed at the Ames Research Center. This "breakthrough" method has been applied to the axisymmetric flow past an AOTV, and the results indicate a substantial increase in computational speed - a significant benefit toward design optimization of future AOTV's.

For rarefied flow regimes, the direct simulation Monte Carlo (DSMC) technique has been found to be particularly well suited to understanding and modeling complex flow problems as represented by the interaction of vehicle airframe, ambient rarefied atmosphere, propulsion system exhaust, and material outgassing. In the DSMC, the gas is modeled by thousands of simulated molecules. Velocity components, internal energy states, and position coordinates of these molecules are stored in the computer and are modified with time as the molecules are followed through representative collisions and boundary interactions in simulated physical space. To date, the DSMC technique has been successfully applied to a number of complex flows including a hypersonic reentry problem and the analysis of large solid-propellent rocket engine exhaust plumes. These advances in computational capability, for both the continuum and rarefied flow regime, will allow us to accurately and confidently predict the detailed flow field environment experienced by advanced aerospace vehicles and thus will be a key element in the successful design of these vehicles.

The direct correlation of flight data, ground experiments, and computations is critical to the development of verified predictive tools required for preliminary configuration analyses and vehicle performance optimization. The completion of recent flights of the space shuttle has provided just such an opportunity for correlation of ground and shuttle data over a diverse range of flight conditions. Flight-derived aerodynamic heat transfer data for the orbiter leeside centerline and wing surfaces have been compared with appropriate ground test results. Flight heating levels are, in general, less than those which are inferred from the ground test results. This result is apparently due to laminar-to-turbulent transition of the flow in the separated region occurring at a much larger Reynolds number in flight than in the wind tunnel.

A detailed aerothermal loads data base is essential to permit proper vehicle structural design while avoiding the tendency to overdesign which can introduce significant mass/volume penalties. Consequently, there has been continued emphasis on the development of an integrated fluid-thermal-structural analysis technique using a finite-element approach that will allow rapid, accurate, structural analysis and optimization of advanced vehicle concepts. The use of finite-element modeling in both the fluid and solid structure will produce a unified analysis with common terminology/methodology throughout. However, the finite-element approach typically requires the solution of large systems of equations and extensive numerical integration which make the analysis of compressible flows prohibitively expensive. Recent advances in solution algorithms are overcoming these limitations by taking full advantage of computer vectorization schemes. Two- and three-dimensional inviscid and viscous flow codes are achieving competitive speeds on modern vector computers. A recent application was successful in describing the complex flow in the shuttle's wing-elevon region where other techniques had failed.

CHANGES FROM 1986 BUDGET ESTIMATE

The increase of $0.2 million in aerothermodynamics research and technology reflects a realignment within the research and technology base to support computational capability for direct simulation techniques.

BASIS OF FY 1987 BUDGET ESTIMATE

Continued emphasis will be placed on computational aerothermodynamics in FY 1987. In the development of advanced continuum flow simulations, generalized three-dimensional geometry modeling, adaptive grid generation, and accurate chemical reaction, models necessary to describe the complex configurations and environments of future hypersonic vehicles will be actively pursued. In the area of DSMC techniques, the current methodology will be extended to cope with entry velocities anticipated for AOTV and lunar return aerobraking missions and for complex vehicle configurations. This will involve the addition of ionization reactions and the mechanisms for nonequilibrium emission and absorption of radiation.

The shock layers about the airframes of high-altitude, high-speed vehicles are characterized by nonequilibrium distributions in chemical composition and energy states of the low-density shock layer gases. These nonequilibrium conditions, particularly nonequilibrium radiative heating, will have very significant influence on aerodynamic and aeroheating environments experienced by these vehicles. To successfully design flight control and thermal protection systems will require a detailed understanding of, and predictive capability for, these phenomena. Computational chemistry, in which the chemical and physical properties of matter are computed from first principles, is making significant contributions to the fundamental understanding of the chemical and physical processes occurring at high-temperature/low-density conditions. In FY 1987, emphasis will be placed on computing chemical and physical properties of air species to simulate the specific conditions of nonequilibrium shock layers. Energy profiles and rate constants for electron-ion and electron-neutral molecule collisions will be computed.

FY 1987 will also be a period of increased activity in hypersonic research ground facilities. The 3.5-foot hypersonic tunnel at the Ames Research Center, currently undergoing reactivation, will be the focus of much of this effort. This tunnel provides a test capability from Mach 4 to 14 and covers much of the hypersonic flight range of anticipated airbreathing vehicles. The initial research program will be a joint Ames/Langley Research Center effort to investigate hypersonic airframe/propulsion interaction effects. This will involve early use of the Ames numerical aerodynamic simulation facility to provide numerical solutions to complex flow problems and for computational configuration analysis coupled with testing in the 3.5-foot tunnel to provide experimental verification.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Space energy conversion research and technology........................	22,312	22,900	21,200	20,400

OBJECTIVES AND STATUS

The objectives of this program are to increase the performance, capacity, and cost effectiveness of space electric power generation and energy storage subsystems; provide the technology for efficient, reliable, and low-cost management and distribution of electrical and thermal energy for space systems; and advance the technology of life support systems for large manned space platforms. In FY 1985, two significant advances in photovoltaic cell technology were achieved. First, the demonstration of a 50-micron lithium counterdoped silicon cell with less than ten percent power degradation after exposure to the equivalent of ten years' radiation in geosynchronous earth orbit was demonstrated. This compares with greater than 25 percent degradation with current operating systems. Second, the superiority of indium phosphide solar cells under 10 million electron volt proton irradiation to any other available space cell, including silicon and gallium arsenide (GaAs), was also demonstrated. A multiyear program was initiated to optimize the efficiency of such cells while maintaining their radiation performance and to demonstrate a 20.4 percent efficient gallium arsenide concentrator cell operating at 80 degrees centigrade and sunlight concentration of 100 times normal levels. Efficiencies above 21 percent are ultimately anticipated. Concentrator photovoltaic systems enable significant reductions in the solar array area and correspondingly in requirements for drag makeup. By focusing the sun's energy, they allow high levels of power to be produced with a relatively low number of cells, permitting the use of efficient but costly cell materials such as GaAs. In addition, concentrators provide protection against damage by natural solar radiation. Concentrator systems appear to be attractive for use in the low-earth-orbit (LEO), relatively high-power space station detached platforms, particularly the planned polar orbiting platform, where radiation levels are more severe. In late 1984, the successful deployment and retraction of a 105x13-foot lightweight solar array demonstrated the technology for power-to-weight ratios of 66 watts per kilogram. A multiyear contract effort was started in 1985 to advance the power-to-weight ratio capability to 130 watts per kilogram. Doubling of the power-to-weight ratio will provide for additional scientific capability by reducing the weight and size of photovoltaic power systems for weight-limited geosychronous and planetary spacecraft. Both welded and soldered interconnects to 2x4cm silicon solar cells survived after 60,000 cycles in a simulated LEO thermal environment (+80 to -80 degrees centigrade), equivalent to a ten-year exposure. Testing of a thin, flexible coating demonstrated atomic oxygen durability of the protective coating on Kapton solar array blanket material equivalent to 21 years of life for space station orbit. Changes in the chemistry and design of nickel-hydrogen batteries have resulted in a sixfold increase in the cycle life and show promise of meeting a 50,000-cycle requirement of LEO systems. As a result of these advances, nickel-hydrogen batteries are now a prime candidate for energy storage on the space station and associated scientific platforms.

In space nuclear power research, a high-temperature liquid metal cooled reactor/thermoelectric conversion system was selected for a Department of Defense (DOD)/Department of Energy (DOE)/NASA ground engineering system test. In research on dynamic conversion systems, development of a Stirling engine for use with solar dynamic and/or advanced nuclear power systems continued. The free-piston Stirling engine offers the potential to provide high efficiency and long life. Projections of power requirements for the evolutionary space station are increasing dramatically, and solar dynamic or nuclear systems are expected to be required to meet these higher power needs. In 1985, the largest free-piston Stirling engine ever built was successfully operated with a linear alternator conversion system. In the thermal management area, technology for use of 50-meter pumped heat pipes/contact radiators for cooling of the space station habitat was demonstrated. Technology for capillary heat pipes for cooling experiments has been successfully ground tested in conjunction with the space station thermal bus system and in zero gravity experiments on the space shuttle. Experimental efforts continued to provide fundamental data on the fluid dynamics and droplet formation processes for liquid droplet and liquid belt radiators. Under the power management program, the development of critical technologies for the space station power management subsystem was completed. This included technology for 20-kilohertz alternating current resonant power distribution, 100-kilowatt class fast-switching transistors and diodes, high-frequency lightweight transformers and capacitors, and high-power roll ring power transfer devices. In the advanced life support technology area, efforts continued on regenerative techniques aimed at achieving a higher degree of closure of the water-air-waste cycle for extended duration manned missions. Technology development has been successfully completed on the electrochemical and solid amine carbon dioxide concentrators and is continuing on low-energy water filtration and supercritical waste oxidation systems.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $1.7 million in the space energy conversion research and technology program reflects reductions primarily in the areas of environmental control/life support and thermal management to provide funding for support of other high priority requirements, including the aerospace industry/university space flight experiments research effort, cryogenic fluid management technology, and transatmospheric technology efforts.

BASIS OF FY 1987 ESTIMATE

Prior to FY 1986, the principal focus of the space energy conversion program was to develop the power and life support technology that would be applicable to the initial space station. This goal had largely been accomplished by the end of FY 1985. In FY 1986, the program was redirected to address the needs of other advanced manned applications and planetary programs and to emphasize innovative technologies that will enable distant, future, ambitious space missions such as lunar base and manned planetary missions. In FY 1987, technology development for high-capacity, long-life solar dynamic and space nuclear power will dominate. Added emphasis will be placed on technologies such as advanced radiators, liquid metal heat pipes, and high-power lightweight power systems, all of which are essential for the high-power systems of the foreseeable future. In addition, development of innovative technologies will be continued. Revolutionary concepts, such as laser power transmission, use of extraterrestrial resources and supercritical water reclamation systems, may be necessary to accomplish ambitious future missions such as planetary exploration and sample return. In space nuclear power, technology development will continue for advanced dynamic and passive thermal-to-electric conversion systems which offer the potential to reduce the weight and nuclear fuel requirements to one-third of current technology systems. Development of high-temperature receivers, thermal storage, concentrators and high-efficiency conversion systems which will double the operating temperature and offer a fourfold reduction in area will continue. Since it is expected that all commercial and most military and NASA scientific satellites will continue to use photovoltaic power systems, a major effort to increase the efficiency and life and reduce the cost and weight of these photovoltaic and associated energy storage systems will continue.

	1985 Actual	1986 Budget Estimate	 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Propulsion research and technology....	20,500	20,900	22,300	21,000

OBJECTIVES AND STATUS

The objective of the propulsion research and technology program is to provide the analytical tools and design activity necessary for improving the life, performance, reliability, and maintainability of chemical and electrical propulsion systems for future space transportation vehicles, manned and unmanned platforms, and spacecraft systems. The program includes efforts directed at providing longer life, reusable, fault-tolerant propulsion systems for future lower cost earth-to-orbit (ETO) operations; high-performance, variable thrust propulsion for increased orbit transfer mission flexibility and capability; efficient, long-life, on-board auxiliary propulsion for precise attitude control, stationkeeping and drag makeup functions; and very advanced concepts capable of greatly exceeding the performance limits of conventional chemical propulsion systems.

Advanced technology for high-thrust (500 thousand to 2 million pounds) high-pressure, reusable propulsion systems is focused on extending the service life of engine components subjected to severe internal dynamic environments, both mechanical and thermal, typical of engines of this class and on understanding and controlling heat transfer in order to enable long combustor service life. These technology advances are directly applicable to next generation hydrogen-fueled and hydrocarbon-fueled engines. Improved single-crystal turbine blades constructed by an advanced processing technique have demonstrated extended low-cycle thermal fatigue life compared to existing directionally solidified blade designs in burner rig testing. A new theory for predicting the life of parts subjected to both low-cycle and high-cycle fatigue has been developed and will be verified initially in laboratory scale tests. A cryogenic bearing thermal model design tool is now in operation and is being validated by bearing tester temperature measurements. Isotope and fiberoptic bearing-wear detectors have been successfully demonstrated in laboratory testing and will be installed in pumps for evaluation in real engine hardware as a part of the advanced earth-to-orbit systems technology program. Finally, in liquid-oxygen/methane combustion tests, experimental heat transfer data has been generated and used to better understand the effect of carbon deposition on heat transfer models for high-combustion pressure operating conditions.

Orbital transfer vehicle propulsion requires very high-performance, variable thrust, long-life concepts, and on diagnostics for the condition monitoring of critical high wear-rate components. Vehicle studies have clearly indicated that multiple, small, lower thrust engines are optimum for aeroassist compatibility and man rating. Subcomponent OTV technologies are currently the focus of the research and technology base program. Enhanced heat transfer combustor wall designs, key to high-pressure combustion operation, have been successfully demonstrated in laboratory scale tests. The compatibility of turbine blade materials with oxygen has also been demonstrated in the laboratory. This is an alternate technique for providing more turbine power for higher combustion pressure operation. High-expansion-ratio nozzle performance prediction will be enhanced through a test program just getting underway that is designed to obtain experimental nozzle performance data. A program to assess advanced materials and fabrication techniques for lightweight high-expansion-ratio nozzles is also underway. Techniques for improving the efficiency of small turbopumps, such as partial admission turbines, high-velocity-ratio diffusing interstage crossovers, and soft wear ring seals, have all shown promise in rig test programs.

Auxiliary propulsion technology is focused on demonstrating the performance and durability of gaseous- oxygen/gaseous-hydrogen thrusters; electrothermal thrusters, including low operating power arc jets; and ion thrusters operating with inert gases such as xenon and argon. Oxygen-hydrogen thrusters designed for long life and high-performance space station auxiliary propulsion requirements have been successfully tested at 25 pounds of thrust for over two hours, delivering higher-than-predicted performance. Electrothermal thruster heating elements, based on tungsten alloys, have demonstrated increased life capability, and the stable operation of arc jet thrusters, operating with a 500-watt and less power level, has also been demonstrated.

Studies are continuing to identify very advanced propulsion concepts and to define the technology that would offer system performance far in excess of conventional propulsion systems. Experimental efforts aimed at reducing cathode erosion in magnetoplasmadynamic (MPD) thrusters continue for pulsed designs. Evaluation of steady-state MPD thrusters is being initiated. In addition, the design, fabrication, and test of a laser-heated hydrogen-powered thruster is underway.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The increase of $1.4 million in propulsion research and technology reflects the realignment of the propulsion portion of the orbital transfer vehicle (OTV) systems technology program to the research and technology base ($1.5 million) which has been offset by a $0.1 million reduction in the propulsion program to support priority transatmospheric technology requirements.

BASIS OF FY 1987 ESTIMATE

Technology efforts for advanced, high-pressure, reusable ETO propulsion systems will continue to be directed toward the development of analytical models designed to simulate internal engine environments and to predict the life of components operating in those environments; the development of components designed for longer operating service life, including advanced bearings, advanced turbine blade materials and thermal barrier coatings, rotor damping devices, improved combustion preburners and main combustors; and the development of high-performance hydrocarbon-fueled combustors. Advanced instrumentation will continue to be developed to more accurately measure the internal dynamic environments of high-pressure engines, as will diagnostic sensors designed to monitor the condition of high wear-rate components. These technology advances will provide the basis for the design of longer life, higher performance engines with automated between-flight inspection, servicing and checkout operation, leading to lower cost access to space.

Technology for variable-thrust orbit transfer propulsion will continue to focus on subcomponent research with the objective of generating analyses and design criteria for engine components critical to achievement of performance, life and maintainability goals for a space-based, man-rated orbital transfer vehicle. Critical components include high-performance, long-life, enhanced transfer combustors; highly efficient variable flow rate turbopumps; and integrated diagnostic instrumentation. Test rigs will be used to validate analytical models and advanced component designs as they evolve. These technologies are key to the operational capabilities of a space-based OTV that will provide lower cost routine transportation to geosychronous orbit and beyond.

Auxiliary propulsion technology efforts will focus on gaseous-oxygen/gaseous-hydrogen thruster development; long-life resistojets with multiple gas operating capability; and high-performance low-power arc jet thrusters. The technologies leading to very high-performance, durable, on-board propulsion systems will provide the basis for reducing propellant resupply, extending the useful lifetime of earth-orbiting satellites, and allowing more useful payloads to be carried on-board (science, transponders, etc.) because of reduced propellant requirements.

Advanced propulsion studies will continue with the objective of identifying promising concepts that offer performance capabilities far in excess of today's conventional propulsion systems. In addition, work will continue toward reducing cathode erosion of high-performance MPD thrusters and toward the design, fabrication, and test of a thruster designed to operate on laser-heated hydrogen.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Materials and structures research and technology........................	18,800	19,300	18,600	18,900

OBJECTIVES AND STATUS

The objectives of the materials and structures research and technology program are to provide for the construction, performance, efficiency, durability, and economy required for large-area space structures, antennas and space platforms, advanced space transportation systems, orbiting spacecraft, planetary probes, and shuttle payloads. Major technical areas of emphasis in materials include initiation and basic understanding of advanced materials; development of computational chemistry methodology; characterization of long-duration space environmental effects on materials; and the development of ceramic, metallic, and advanced carbon-carbon thermal protection systems. Structures technology is directed toward development of advanced truss structural concepts; reliable methods for deployment/erection and repair of space structures; new structural and tankage concepts for advanced earth-to-orbit rocket and airbreathing space transportation systems, and orbital transfer vehicles; and efficient analytical methods for design and evaluation of advanced space structures, including integrated structures/thermal controls analysis, optimization techniques, and structure/controls interaction methodology.

A key element for structural dynamics research during FY 1986 was the implementation of a focused program for the dynamic response and passive/active control of flexible space structures. This activity encompasses a variety of large space structures that include joint-dominated deployable beams, flexible platform structures, and antenna structures. The major program goal is to develop validated structures/controls analysis methods which will then allow detailed design studies that can assess technology merits between utilizing structural stiffness, passive damping techniques, and active control methods to attain specified system performance and accuracy requirements. As part of the ongoing space construction research activities, an in-space shuttle-bay structural assembly experiment was conducted in early FY 1986. This experiment involved the construction of a joint-dominated truss from the cargo bay of the space shuttle by two astronauts to obtain data to evaluate on-orbit assembly and repair techniques. Preliminary data show good agreement with ground-based studies in the neutral buoyancy facility. A data base of assembly and repair timelines is essential for space station and other large space construction in the future.

In FY 1986, ground testing of a 15-meter deployable hoop-column antenna to understand its modal vibration response will continue. The data obtained from this complex, cable-stiffened structure will serve as a basis for the development of future analytical dynamic models. Additionally, research in structural dynamic response is resulting in the completion of the nonlinear analysis of a generic, multibody, flexible, large space structure. This research is necessary to enhance understanding and lead to the development of suitable active and passive control technology for stable structures.

Materials research in FY 1986 focused on the effects of the space environment. Material behavior must be understood to ensure long-life survivability of space structures. The area of atomic oxygen interaction with materials received considerable attention. Ground-based facilities to simulate space effects were established in preparation for a December 1986 flight experiment to validate analytical models. Emphasis was placed on developing space-durable polymeric composite materials and protective coatings and the study of methods for nondestructive testing and evaluation. Supporting research was conducted to understand the mechanisms controlling surface properties of materials in a space environment.

Increased emphasis was placed on the technology requirements for an aeroassisted orbital transfer vehicle and an aerospace plane vehicle. Part of the assessment process for advanced thermal protection systems (TPS) concepts included exposure to an arc jet to simulate the reentry environment. Extensive research for advanced TPS will continue in FY 1986. The effort is focused on advanced silicon-carbide composite concepts and other ceramics in the form of tailorable advanced blanket insulation. Three-dimensional weaving procedures were developed, resulting in blankets of significantly greater durability.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $0.7 million in materials and structures research and technology reflects the consolidation of base funding for control of flexible structures flight experiment into the space flight research and technology base program.

BASIS OF FY 1987 ESTIMATE

The effect of the space environment on structural materials for spacecraft, space station, and orbital transfer and transatmospheric vehicle applications will be a major program activity. Included in this activity will be research on the durability of polymeric materials, thermal control coatings, films, adhesives, and seals. The radiation damage mechanism in epoxy matrix composites tested in a ground-simulated space environment for geosynchronous earth orbit will be identified. This program continues the accelerated testing of these materials in the combined space radiation environment of electrons, protons, vacuum and ultraviolet. Analysis of both ground-based and flight data on atomic oxygen effects will be carried out to determine mechanisms involved. New protective coatings will be developed. Thermal control coatings research to allow full benefit of composite structures for large-area space application and the study of the dimensional stability of composite structures in the space cyclic-thermal environment will continue. Basic research on materials for space power systems, particularly in the area of fluid heat exchanger capability, will be increased to better understand material compatibility issues to ensure long-term system life.

Advanced carbon-carbon and ceramic composite concepts will remain a major focus in the thermal protection systems program. Activities in the ceramic thermal protection system area will continue to be directed toward the further development of flexible ceramic blanket-type insulation for application to advanced orbital transfer vehicles and for further upgrade of material currently used on the shuttle. The new system will cost less and will be more durable. Both rigid and flexible TPS will be evaluated for use on a rapid-response aerospace plane.

Research in advanced space structures will establish structural concepts, deployment schemes, and packaging techniques that will permit structures on the order of 100 to 200 meters in size to be carried into orbit in one shuttle flight and automatically deployed. Erectable concepts and assembly methods for structures between 100 and 1000 meters in size will be developed. Research on a multijointed flexible 20-meter beam will be performed to establish the technology base for the control of flexible structures dynamic response with the goal of conducting in-space structural dynamics flight experiments to validate the technology. This activity will require both analytical and experimental research to develop procedures to characterize structural configurations during ground tests, as well as during space tests. Active and passive damping techniques to reduce structural vibration will be developed in parallel with the development of methods for predicting and reducing the dynamic response of structural configurations for large-area space platforms and antenna structures.

A coordinated program for research on advanced analytical methods will be conducted in FY 1987. This program is aimed at developing, testing, and verifying solution algorithms utilizing supercomputers. New, extremely fast and efficient structural analysis methods are essential to the design, analysis, and performance of large-area space structures, aerospace plane vehicles, and other space structures. Advanced analytical methods that include deployment dynamics and mechanisms simulation will be continued for analysis of large, flexible space structures and platforms. Additionally, research to develop improved integrated fluid-thermal-structural analysis capability will continue with focus on generic configurations to allow for the development of highly efficient, stable structures for high-speed flight. New innovative concepts and joining processes for fabricating lightweight high-temperature structures for advanced space transportation vehicles, including earth-to-orbit vehicles, will be developed.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Space data and communications research and technology.....................	16,500	16,900	16,000	13,600

OBJECTIVES AND STATUS

The space data and communications research and technology program is directed toward controlling, processing, storing, and manipulating space-derived data and enabling new concepts in satellite communications.

The objectives of the data systems efforts are to provide the technology to enable affordable utilization of space-derived information; to increase substantially the capability of on-board processing for future missions; and to provide computational systems anticipated for evolutionary space station. Development work is nearing completion on the massively parallel processor to be used in Landsat data reduction and the ten-terabit optical-disk juke-box system to be used to support a nationwide space science data base network. Development of the high-bandwidth terabit optical-disk buffer system intended for space station and other flight applications is underway. Individual elements of the technology needed to produce the buffer have been demonstrated and are now being assembled into a demonstration unit. Work is underway to obtain, evaluate, and assemble processors from the very advanced integrated circuits that are now becoming available for space applications. Advances in on-board processing and storage will allow the migration of ground-based data processing to the space station, thus enabling substantial savings in operations cost.

The communications technology effort provides the necessary research and technology required to maintain and ensure the U.S. preeminence in satellite communications. Fundamental research in microwave tubes has led to the development of a 100-watt, 60-GHz (gigahertz) traveling wave tube to provide high-bandwidth microwave communications capabilities for intersatellite links for the advanced tracking and data relay satellite systems. An eight-beam overlapping-cluster microwave feed has been developed to demonstrate that antennas with contiguous multiple beams can be designed with very low sidelobes for optimum ground cover and frequency. Also, a 15-meter hoop-column antenna was designed and successfully tested with the eight-beam feed. Large-aperature feed and antenna technology is aimed at opening new space communications markets for mobile applications and for the very large baseline interferometer (VLBI) science mission. Recent results from our large-aperature feed and antenna experiments provide the opportunity for on-orbit antenna shape adjustment capability which could significantly reduce the cost of assuring precision shape. An X-band dielectric resonator oscillator with excellent temperature stability and low-phase noise has been developed which replaces the more expensive and error-prone frequency multiplier chains previously employed in spacecraft transponders for application to the Mariner Mark II series of planetary exploration spacecraft. A 20-GHz monolithic microwave integrated-circuit transmit module has been successfully built and tested. This module consists of five-switched line phase shifter circuits with control logic, a buffer amplifier for phase compensation, and a power amplifier contained on a single chip. This technology is necessary for the development of low-weight and cost-effective phased array feeds for large antenna systems.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $0.9 million in space data and communications research and technology includes the transfer of $0.4 million of automation funding to the automation and robotics systems technology program; a decrease of $0.4 million to support the aerospace industry/university space flight experiments effort; and a decrease of $0.1 million in precision antenna research, which has been redirected to support transatmospheric technology efforts and other high priority requirements.

BASIS OF FY 1987 ESTIMATE

In data systems, the program provides computing technology for upcoming NASA missions with emphasis on the needs of space station and associated platforms. The data systems program takes substantial advantage of related development work done by DOD or other government agencies and is coordinated with those agencies. Very high-performance, high-speed processors will be assembled for NASA applications from modular components from the DOD very high-speed integrated circuits (VHSIC) program. A very highly reliable processor for use in high radiation environments will be assembled and tested to extend the life and performance capabilities of low-earth-orbit and planetary spacecraft. Spaceborne processors to meet very specific and demanding requirements of scientific instruments will be developed as special adaptations of processors for other government applications. The high-bandwidth terabit optical-disk buffer will be demonstrated for application to space station development. Work in developing high-speed fiber-optic modules for space applications in conjunction with the Air Force will continue. This technology is applicable to space station and the earth observing system for the distribution of high rate data between subsystems. Work will be initiated to investigate applications for very fast and high-capacity associative memory technology.

In FY 1987, the 60-GHz traveling wave tube (TWT) will be mated with a multiple-depressed collector with an expected twofold enhancement in efficiency. Also, a 60-GHz TWT will be specifically designed for power levels and bandwidths commensurate with a demonstration of communications between satellites at rates in excess of 300 million bits per second. A programmable adaptive phased array feed will be employed with the 15-meter hoop-column antenna to prove the theoretical concept of using phase and amplitude of the feed to compensate on-orbit for surface deformations of the antenna in order to provide the ideal far-field antenna pattern. Work will also be initiated on unique adaptive feed concepts with frequency reuse and contiguous multiple beams, a goal with revolutionary implications for large antenna systems technology. The major goal of the monolithic microwave integrated circuit research for FY 1987 will be to build a prototype 20-GHz feed, complete with the necessary phase and amplitude integrated circuits and control logic, and test this on an appropiate antenna in the Lewis Research Center's near-field facility. This work will ultimately enable the development of cost-effective, low-weight electronically steerable antennas, a technology that will dramatically increase the science returns of both low-earth-orbit and planetary missions. The X-band transponder demonstration technology will be completed and transitioned to the Office of Space Science and Applications for application to the Mariner Mark II series of missions. Included in this will be the successful design and demonstration of an engineering model of a 5-watt X-band solid-state power amplifier with record efficiencies of approximately 40 percent. Two-dimensional laser array technology for optical communications both in near-earth and planetary applications will continue. In particular, a new solid-state optical detector employing a superlattice-type construction will be built and tested. This device could allow operation of future optical communications systems at bandwidths in excess of one gigabit per second.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Information sciences research and technology........................	17,590	18,000	9,900	10,200

OBJECTIVES AND STATUS

The objective of the information sciences research and technology program is to provide advanced concepts, techniques, system architectures, hardware components, algorithms, and software for space information systems. The program contains disciplinary activities in computer science and sensor systems. The computer science program is improving the state of knowledge of fundamental aerospace computing principles and advancing computing technology in space applications such as spacecraft operations and information extraction from images. Advances in information science are necessary to cope with the explosive growth in the quantity and complexity of space-acquired data. Sensor research is focused on extending the capabilities of active and passive sensing systems in terms of NASA's unique requirements for spectral range, sensitivity, and resolution to enable future science and applications mission objectives.

In computer science, research in the fundamentals of data base logic have resulted in the development of a common user interface for accessing data from several data bases, even when the data bases being accessed have very different structures. This work provides the foundation that will enable NASA space data users access to multiple data bases independent of their physical distribution or structure. This research will reduce the cost of data base intensive research that would otherwise be unaffordable.

New approaches to software management will be evaluated in ongoing software production facilities. An experiment to test the validity of a simulation-based cost model for the software life cycle will be starting. Studies of parallel algorithms and principles of concurrency are underway and are yielding information on how to use the largely unexploited capabilities of parallel processors. The developmental work on the massively parallel processor is now concluding. That processor is now transitioning from its developmental role into an operational one to support research requiring very powerful computing capabilities. Researchers at 14 universities, 8 research laboratories, and 3 NASA centers are using this computer to evaluate its unique capabilities for image processing.

In the sensor technology program, a Raman-shifted, efficient, ultraviolet excimer laser under development will be used to demonstrate the feasibility of active remote monitoring of stratospheric ozone from the ground-based light detection and ranging (LIDAR) facility for eventual space application for the earth observing system (EOS) mission. In the area of solid-state lasers, results of experimental measurements of potential laser materials and dopant ions indicate that materials which exhibit broad fluorescence emission will also be capable of tunable laser operation over broad wavelength regions, a feature of importance in active remote sensing. In addition, research is being done on two-dimensional arrays of semiconductor lasers with emission energy densities greater than a kilowatt per square centimeter to replace flashlamps for laser pumping for use in missions such as EOS.

In conjunction with the California Institute of Technology, a superlattice diode has been built which offers the potential of integrating the detector with the laser and other active devices on the same chip and having the device voltage-tune over wavelength regions of interest enabling wavelength adaptive space sensor capability. The development of an antimony doped silicon array has extended the capability of space infrared sensors to 30 micrometers with an order of magnitude lower readout noise. This device will find application on the large deployable reflector mission. An X-ray imaging spectrometer has been invented that will analyze X-rays in the 1- to 30-kiloelectron volt region which is an important science objective of the advanced X-ray astronomical facility.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $8.1 million in information sciences research and technology reflects the transfer of automation and robotics funding to systems technology and a reduction in information sciences of $0.3 million in order to support priority transatmospheric technology efforts.

BASIS OF FY 1987 ESTIMATE

In computer science, the knowledge-based techniques that have been demonstrated as applied to hyperspectral scene analysis for geologic remote sensing will be expanded and shared with other users to demonstrate the usefulness and portability of the approach to the analysis of space-acquired data. The distributed access and view integrated data base work will focus on applying this capability to selected pilot space data systems.

A major emphasis is being placed on the coordination of NASA and DOD software technology programs. ADA has already been selected as the language for space station, and efforts will be continued to maximize the benefits from use of that language. Special efforts will continue to coordinate NASA technology with the DOD software technology for adaptable reliable systems program and the DOD Software Engineering Institute. Software engineering research leading toward improved techniques and tools to produce and manage large and complex software development tasks will continue. Software engineering advances will be combined in a showcase aerospace software production environment which will reduce the cost of all future space software development efforts.

The Center for Aeronautics and Space Information Sciences at Stanford University will continue as a center of excellence in aerospace computing, conducting research and educating students in concurrent processing, networking, information management, and large-scale system architecture.

In the sensors program, work will continue on detector arrays for background-limited observations for space-based astronomical observations. Techniques such as impurity band photodetectors and stressed photodetectors will be investigated for extending the sensitivity out into the very far infrared and into the upper part of the submillimeter portion of the electromagnetic spectrum. Superconducting mixing devices with wide-band gap materials will be investigated for use at mid-submillimeter wavelengths. Research on arrays of mixers for simultaneous spatial and spectral imaging will be initiated. Submillimeter sensing technologies are targeted at atmospheric and astronomical sensing missions. These technology efforts are aimed at providing scientists with the remote sensing capability in the submillimeter region of the electromagnetic spectrum. Pumping of solid-state lasers with various geometrical arrays of semiconductor diodes will be pursued for active remote sensing. Also, new solid-state crystals with large degrees of tuning bandwidth, together with doubling crystals, will be investigated for reaching previously unattainable wavelengths. These laser sensing technologies will be evaluated on the lasers in space technology experiments and are targeted for application on EOS.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Controls and guidance research and technology...........................	8,600	8,900	7,500	7,500

OBJECTIVES AND STATUS

The space controls and guidance research and technology program goals are to generate the practical design methods and techniques required to enable precise pointing and stabilization for future NASA spacecraft and payloads; to maintain precise structural shape control for highly flexible large space systems; and to guide, navigate, and control advanced space transportation vehicles. Emphasis is being placed on advancing the methodology of combining both ground-based testing and future space-based testing with modern control theory to validate advanced flexible body modeling techniques and control laws.

Recent program accomplishments include the successful demonstration of distributed active control in improving disturbance suppression damping by a factor of five or more, a result important to the NASA planned pinhole occulter project and planned mobile communication satellite ventures; the completion of the spacecraft control laboratory experiment test article for the testing of new spacecraft pointing control algorithms important to large flexible astrophysical reflector telescopes; system identification programs which can accurately determine, on orbit, the vibration modes in large space systems, such as growth space station; the successful breadboard test of a unique three-dimensional shape and motion sensor useful for determining the behavior of large flexible structures in space, such as will be tested in the control of flexible structures flight experiments; and the invention of a novel soft-mounting isolation device which uses a newly available piezoelectric polymer as the control actuator for supporting precisely pointed payloads on space station. Practical guidance laws were generated from optimal navigation control theory for a wide range of aeromaneuvering orbital transfer vehicles. Also, in the transportation system vehicles area, a very successful laboratory test was completed for the all solid-state fiber-optic rotation sensor, satisfying a wide spectrum of transportation vehicle requirements for a reliable, long-life, autonomous, precision navigation capability. A broad technology plan was completed to guide the overall transportation vehicle program's future activities.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $1.4 million in controls and guidance research and technology resulted from the following actions: realignment of $0.2 million for control of flexible structures to space flight research and technology; reduction of $0.7 million in space platform operations to support the aerospace industry/university flight experiments effort in the space flight research and technology budget line; transfer of $0.4 million in the teleoperations area to the automation and robotics systems technology program; and realignment of $0.1 million to support priority transatmospheric technology efforts.

BASIS OF FY 1987 ESTIMATE

Specific FY 1987 controls and guidance research activities will include further theoretical exploration of modern control theory methods associated with system identification, distributed control and adaptive control, and definitive testing of competing methods in ground test facilities. The goal is to identify and validate the most effective control concepts for in-space tests aboard the control of flexible structures flight experiment. The unique three-dimensional shape and motion sensor is being extended to a multitarget capability for a precise shape measurement of realistic three-dimensional large space structures such as the land mobile satellite and space station. The precision soft-mount elements, useful for space station mounted payloads, will be fabricated and breadboard tested under realistic space station disturbance environment.

In the advanced transportation systems area, the technical challenge will be met for solutions for aeromaneuvering vehicles undergoing skip trajectories, synergistic plane changes, and precise landings involving large downrange and crossrange capability. The advancement of the very promising all solid-state fiber-optic rotation sensor for navigation will be continued to provide transportation vehicle and interplanetary spacecraft requirements for long life and reliability. A substantial effort will be devoted to examining the concept of the control-configured space transportation vehicle, a vehicle which depends largely on the rapidly advancing areas of controls technology for its performance, stability, and economy of operation.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Human factors research and technology...........................	3,700	4,000	2,300	2,300

OBJECTIVES AND STATUS

The objective of the space human factors research and technology program is to provide the technology base for productivity, efficiency, and safety in increasingly complex manned space operations, including the space station and a potential national aerospace plane. The research is focused on crewstation design and productivity enhancements for extravehicular activity (EVA). The objective of the crewstation design effort is to determine the requirements for effective interfaces between human operators and advanced automation. This issue has become very challenging due to the increasing levels of machine intelligence and autonomy sought by system designers. Instead of performing low-level sensor integration and determining actuator positions, the human operator is becoming a supervisor of intelligent systems. For example, an expert system interface has been designed for an orbital refueling system with fault diagnosis and explanation strategies developed from simulated operational experience.

Effective information transfer between the system and the operator is fundamental to the operation of highly automated systems. Current research has guided development of a wide field-of-view stereo helmet- mounted display for remote manipulation, algorithms for machine vision, and guidelines for improved proximity operations displays.

One thrust of the crewstation design effort is to ensure that human/computer interaction technology developed outside the agency is adapted to NASA's unique aerospace needs. As part of this effort, a project is underway to develop comprehensive guidelines derived from research by industry, the military, and academia. An advisory group has been created and has formally reviewed initial sections of the guidelines. Formal publication is planned for FY 1987.

A second broad thrust is the development of rapid prototyping methodologies for crewstation design. The idea is to bring together very advanced research concepts in working demonstrations and to obtain user evaluations early in the research and development process. This encourages focused research which addresses the needs of the user community. Rapid prototyping is being applied to a wide field-of-view stereo display for enhanced situational displays. The device is a major breakthrough in engineering design because it has achieved very high functionality at very low weight, power, and cost. It will sigificantly augment visual feedback in teleoperations tasks on space station. Currently, two versions of the display system have been built based on liquid crystal technology. Liquid crystal display technology allows low cost, high functionality, and ruggedness. An advanced version of the video processor has been built and holographic optics are being designed. Holographic optics will reduce the weight of the system and allow very compact packaging.

To encourage rapid prototyping at the systems level, a space station proximity operations workstation mockup is being built to bring together a wide array of advanced research concepts, including voice interaction automated systems, intelligent system interface software, three-dimensional perspective displays, spatial aural displays, and exterior window concepts. Currently, the display and control hardware is being assembled in a cylindrical module. Researchers in each of the above areas have projects which they are preparing for integration into the module. These include an expert system for human interface to the in-orbit refueling system, innovative display formats for space traffic control and EVA monitoring, and a working helmet-mounted display. The space station proximity operations workstation will be used to test advanced concepts for human/automation interface. Proximity operations scenarios will be utilized for these studies.

Interaction with automated (expert) systems is a third major thrust of the crewstation design effort. Effective coordination of automated and human-controlled functions is required for NASA's increasingly complex missions. Improved crew interface to automation will allow reduction of ground support requirements and greater crew productivity, even as operational demands increase. In particular, studies are underway to determine how best to interact with automation which shares system expertise, authority, and control with the human operator. One of these studies uses an orbital refueling system simulator and expert system for explanation of operator/automation interface experiments. This study has shown that operators require explanation of higher level situational implications of "out-of-tolerance" conditions.

A very successful research project in laser anthropometry supports both crewstation design and EVA performance. The system is installed and in full operation. This unique tool allows the three-dimensional position of an astronaut to be recorded rapidly and accurately; the data are then reconstructed into geometric form for analysis of astronaut activities. This allows automated tests of proposed workstation layouts, as well as determination of the feasibility of specific EVA tasks. The laser anthropometry system is being augmented by addition of a strength and motion data base. Experiments are underway to obtain data for the upper body.

Other support for EVA includes a space helmet-mounted display which can be used to display suit status and EVA task guidance information. This system has been prototyped and is currently undergoing integration tests and initial format development. The space human factors program is also contributing to the agency's development of a hard spacesuit. A hard spacesuit will allow astronauts to exit the spacecraft without several hours of prebreathing, because it operates at the same high atmospheric pressure as the spacecraft cabin. Two high-pressure demonstrator suits are being built and tested.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $1.7 million in human factors research and technology reflects the transfer of the teleoperations effort ($1.6 million) to the automation and robotics systems technology program and a realignment of $0.1 million to support transatmospheric technology efforts.

BASIS OF FY 1987 ESTIMATE

Research in FY 1987 will emphasize crew workstation design with a lesser effort in EVA aids. A comprehensive set of human factors guidelines which are specific to NASA's missions will be published and distributed to space station contractors. The proximity operations mockup will be a mature facility for support of rapid prototyping, and advanced research concepts will be brought in for systems-level evaluation and comment by users. By FY 1987, research on the wide field-of-view stereo display will be ready to support an advanced virtual display capability. The virtual display is a major leap beyond current computer display technology. It allows computer-generated graphics and text to be displayed anywhere in the user's workspace, which greatly improves the information transfer capability of spatial information displays.

Expert system interface analyses will develop multilevel system models and other strategies to enable systems and users to communicate efficiently about system status and fault diagnosis. Laser anthropometry work will include the completion of efforts to model the strength and motion parameters of the upper body, and similar modeling work for the lower body will be initiated. Software enhancements will improve the user interface to the anthropometry data base. Efforts will begin to integrate the anthropometric data base with other human factors computer-aided design tools. Operational formats will be developed for the space helmet display and evaluated for application to EVA tasks. Research to support the high-pressure hard spacesuit effort will focus on new approaches to flexible but durable gloves that can be used comfortably at high internal pressures. Higher suit pressures cause gloves to be less flexible, which increases chaffing and other discomforts. High-pressure gloves have also suffered unacceptable fatigue failures.

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Space flight research and technology........................	11,468	11,900	17,400	22,400

OBJECTIVES AND STATUS

The objective of this program is to provide a research-quality flight data base for the validation of ground-based research and technology efforts required for the development of future space systems and operations. This objective is accomplished through the utilization of the space shuttle as an in-space research laboratory. Flight data obtained from this effort provide a foundation for the development, refinement and verification of analytical theories and ground facility performance, test methods, and techniques. This program encompasses the design, development, and flight test of experiments and the development of special purpose, reusable, flight research facilities for use in space.

Under the orbiter experiments program (OEX), shuttle flights have included key aerodynamic and aerothermodynamic experiments on orbiter vehicle 102. These experiments included low- and high-altitude research-quality air data systems for the measurement of air density from the upper atmosphere to touchdown and an infrared scanner in the vertical stabilizer to measure entry heating on the shuttle upper wing and fuselage surfaces. Also, during FY 1986, the second flight of an adaptive autopilot will have demonstrated autonomous rendezvous with a real target. This experiment has demonstrated an automated rendezvous and docking capability that will provide significant benefits to future space operations and, in particular, to future space station operations. In late FY 1986, flight testing of advanced thermal protection system test panels will be initiated. These panels will provide actual flight data on durable, high-performance concepts which could become candidates for future aerospace vehicles. The orbiter acceleration research experiment will provide accurate aerodynamic acceleration measurements during orbit and reentry and will make significant contributions to the data base for the rarefied and transitional flow regimes. This data base will be used to predict drag forces more accurately on large space structures to enable accurate prediction of propellant usage for orbit maintenance and attitude control. This experiment has completed critical design review in preparation for hardware development and a planned flight in the 1988 time frame.

An aeroassist orbital transfer vehicle (AOTV) offers the potential of utilizing atmospheric forces rather than a propulsion system to achieve desired orbital changes. For some missions, the propellant savings of an AOTV, as compared to a conventional configuration, is estimated to be sufficient to allow nearly double the payload for the same size vehicle. The AOTV flight experiment will release a test vehicle from the orbiter payload bay to be raised in orbit, then accelerated into the atmosphere to simulate the aerobrake maneuver, and recovered into the payload bay. During the maneuver, data on aerodynamic, aerothermodynamic, and thermal protection system response will be achieved. Ground-based wind tunnels are not capable of simulating the aerobraking environment. This experiment is currently in concept definition in preparation for the Phase C/D (design, development, and flight test) initiation in FY 1988.

The cryogenic fluid management flight experiment, which provides basic understanding of the storage, acquisition, and transfer of cryogenic fluids in zero gravity, will complete systems level preliminary design efforts, the Phase I ground safety reviews, and the installation of the cryogenic systems analysis model on the Cray computer. This technology is critical to the design of future cryogenically fueled orbital transfer vehicles (OTV) and for the on-orbit supply and resupply of cryogens to both spacecraft and platforms in that it will provide the technology to design cryogenic systems to minimize propellant boiloff during storage and transfer and thus provide operating efficiencies that will significantly reduce the transportation costs associated with space-based OTV's.

The definition of a hypersonic technology flight experiment will be initiated in 1986 to provide experimental flight data applicable to high-speed aerospace vehicle performance in the high Mach number and altitude regimes to validate aerodynamic and aerothermodynamic computational capability and the behavior of advanced material components and actively cooled thermal structures components.

The development of a space technology experiments platform (STEP) was initiated in FY 1985 to provide a dedicated support system which will be used to conduct flight experiments to study the control of flexible structures in space. STEP is configured to accommodate a broad range of experimental objectives to study the effects of microgravity, wide thermal excursion, and absence of atmospheric damping which are characteristic of the space environment. STEP, as a reusable payload support system and standard orbiter interface, will provide a cost-effective means for routinely conducting a variety of experiments on-board the shuttle.

The long-duration exposure facility awaits retrieval by the shuttle and subsequent data analysis. The ion auxiliary propulsion system remains in flight-ready status for flight on an Air Force satellite. A conceptual design of a plume experiment was initiated, and two heat-pipe experiments, the capillary pump loop and the space station heat-pipe advanced radiator element, will complete flights in FY 1986.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The increase of $5.5 million in space flight research and technology includes the consolidation of funding from other research and technology base programs for the following activities: control of flexible structures ($0.9 million), transatmospheric technology ($1.0 million), aerospace industry/university space flight experiments program ($2.0 million), and cryogenic fluid management technology ($0.1 million). In addition, the aeroassist portion of the OTV systems technology program ($1.5 million) was transferred to this research and technology base program from systems technology.

BASIS OF FY 1987 ESTIMATE

A new focus in FY 1987 is the expansion of the flight experiments program supporting base research and technology activities. This will be accomplished by a directed activity that will extend flight experiment opportunities to the aerospace and academic communities.

Significant activity will occur in the orbiter experiments program: the aerodynamic/aerothermodynamic instrumented flight initiated in FY 1986 will continue through a six-flight series concluding in approximately mid-1987; the thermal protection system panels, also installed on the orbiter in FY 1986, will continue flights on orbiter vehicle 102 through FY 1987 and conclude in FY 1988; and the hardware development for the orbital acceleration research experiment will be initiated.

The aeroassist flight experiment will continue through systems design definition. The hypersonic technology flight experiment will continue requirements definition and design activities leading to a potential flight in the 1988-1989 time frame.

The cryogenic fluid management flight experiment, the space technology experiments platform, and the solid-state laser light detection and ranging in-space technology experiment will initiate hardware development in FY 1987 to prepare for future flight dates. The plume survey experiment will complete preliminary design in preparation for hardware development leading to flight in 1990.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Systems analysis......................	6,788	6,600	6,800	6,100

OBJECTIVES AND STATUS

The objectives of the systems analysis program are to: (1) conduct systems analyses to identify technology requirements for spacecraft systems, space transportation systems, and large space systems for the national space program; (2) integrate these requirements into a comprehensive technology plan; and (3) provide data to establish the ability to develop these technologies in a timely manner. Close coordination with NASA flight program offices and other users is maintained to ensure proper prioritization of enabling high-leverage technologies.

Spacecraft systems are subdivided into planetary systems, communications, earth sciences, and astronomy applications. In FY 1986, the planetary systems analysis has focused on technology needs for high priority missions, with continued emphasis on comet and planetary sample return missions. In communications, the emphasis is to identify, assess, and prioritize high-leverage enabling and enhancing technologies. These studies show that a concerted technology program could potentially double payload fractions, thereby increasing the spacecraft mission accomplishments and reducing costs. In earth sciences, the focus is on earth observing systems (EOS) where interactions between instruments and subsystems will be addressed on an interdisciplinary basis to achieve a total spacecraft system technology plan. In astrophysics, activities will include the design of a subscale large deployable reflector optics breadboard. This work will be supplemented by a pre-Phase A study with the Office of Space Science and Applications. The Office of Aeronautics and Space Technology capabilities in large space structures will be used to support missions and technology tradeoff studies in most of the spacecraft system areas under study.

The space transportation systems analyses are focused in three areas: advanced earth-to-orbit vehicles (ETO), aeroassist orbital transfer vehicles (AOTV), and advanced space transportation systems conceptual design and analysis methods. The ETO area includes the technology to support replacement shuttle (Shuttle II), the heavy-lift launch vehicle and very advanced (post-2010) future space transportation systems. The FY 1986 ETO studies/analyses are focused on Shuttle II and the impact of liquid-oxygen/hydrocarbon (LOX/HC) engines on reusable ETO configurations. The FY 1986 ETO studies also include the definition of nonintrusive instrumentation and measurements applicable across the speed range during ascent and entry of an ETO vehicle. Shuttle II efforts will identify and prioritize enabling and high-leverage technologies required for a transportation vehicle that operates between earth and the space station for logistics, crew change-out, up and down payloads and, in some cases, platform and satellite servicing. This vehicle will be consistent with the national space transportation architecture. The LOX/HC engines/vehicle integration and design studies are being used to assess the impact on reusable transportation vehicle performance and cost. The use of LOX/HC engines, which require very high-density propellants and thus significantly smaller propellant tanks, has the potential for large reductions in dry weight and large reductions in cost per pound of payload to orbit. AOTV technology and environment studies are continuing in FY 1986 but are concentrated on cislunar transportation systems -- in particular, on the identification of the class or classes of AOTV's that will be required to operate between lunar orbit and low earth orbit (LEO). The application of aeroassist braking to the OTV on return to LEO has the potential for a 50-percent reduction in propellant requirements and cost and a corresponding increase in payload to orbit. These studies are consistent with the renewed interest in lunar and planetary colonization and mining. Finally, conceptual design and analysis methods are needed to conduct required trade studies in a most efficient and cost-effective manner. This involves the update and development of the necessary analytical and numerical tools including the computer-aided engineering software and the technology and cost data base.

In the area of large space systems, both manned and unmanned, the analysis program is undergoing a transition in focus from technology for IOC space station to technology for evolutionary growth configurations in the late 1990's and beyond. Additionally, analysis activities have been started to identify in-space research and technology programs which would utilize the space station as a research facility in space, and to begin identifying technology requirements for a manned geosynchronous platform, a manned lunar base, and a manned Mars expedition.

In FY 1986, there are three specific activity areas in the large space systems analysis program: (1) systems analysis methods; (2) future space stations including the evolutionary growth space station in low earth orbit, a manned geosynchronous platform, a manned lunar base, and a manned Mars mission; and (3) in-space research, technology, and engineering program planning. The objective of the systems analysis methods is to maintain development of advanced analytic simulation/emulation computer-based capabilities for determining the operational characteristics of large space systems, predicting nominal and worst-case failure modes, and identifying critical system/subsystem interfaces. The objective of the second activity area, future space stations, is to address mission and system requirements to identify associated technology needs and trends. Specifically, efforts will continue for developing generic space system models to permit the conduct of sensitivity trades for large in-space systems.

Additional tasks will investigate technology needs for such activities as construction of lunar structures, propellant and oxygen production from lunar oxides and Martian permafrost and atmosphere, food production for lunar and Martian missions, and in-flight training for long-duration interplanetary missions. The activities in the third area are associated with developing a technical basis for conducting in-space research, technology, and engineering experiments using the space station as a laboratory facility. Three areas are being investigated for potential in-space experiment programs: fluid behavior, space environment, and structural dynamics and control.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The increase of $0.2 million in systems analysis reflects an internal research and technology base realignment to provide for additional study efforts.

BASIS OF FY 1987 BUDGET ESTIMATE

In spacecraft systems, the analysis effort has identified technologies that will be needed to support the spacecraft technology driver missions. Efforts will continue to build upon these initial results by conducting detailed follow-up to the 1985 large deployable reflector (LDR) workshop; analyzing large space structures with focus on LDR and improving mobile communication satellite (termed MSAT) capability; assimilating the EOS technology workshop results and issuing a comprehensive technology plan; and conducting mission analysis and system technology studies on planetary and sample return missions.

The transportation systems analysis effort in FY 1987 will continue the definition of key areas for technology growth in orbital transfer vehicles and advanced systems for delivery of payloads to low earth orbit. The analyses will focus on concepts and technology requirements for a lunar orbital transfer vehicle, a heavy-lift launch vehicle, and the replacement shuttle. The continued development of design and analysis tools and the technology base for advanced transportation vehicles will enable the development of economical space systems in the future.

In large space systems, with the planning and definition activities associated with the early space station nearing a point in time when applicable technology will be baselined, the systems analysis program will be refocused to address the needs and opportunities of a broader menu of space systems including large antennas, unmanned platforms, and evolutionary space stations. The primary intent of the extended perspective is to ensure that the research and technology base program is structured to support the needs of these missions as they are being projected for the turn of the century. Additionally, the FY 1987 program will continue to expand the efforts started in FY 1986 to include planning for using the space station as a facility in space for technology development.

BASIS OF 1987 FUNDING REQUIREMENTS

SYSTEMS TECHNOLOGY PROGRAMS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Chemical propulsion systems technology..........................	2,100	5,800	5,800	8,100
Space flight systems technology.......	6,642	6,200	6,200	---
Control of flexible structures flight experiment..................	---	5,000	5,000	11,300
Orbital transfer vehicle technologies	---	3,000	---	---
Automation and robotics technology....	---	---	10,200	18,000
Total.............................	8,742	20,000	27,200	37,400

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Chemical propulsion systems technology				
Advanced earth-to-orbit systems technology........................	2,100	5,800	5,800	8,100

OBJECTIVES AND STATUS

The objectives of the advanced earth-to-orbit systems technology program are to validate technologies being developed for advanced high-performance reusable engines by utilizing a testbed engine assembled from existing space shuttle main engine hardware for the purpose of providing experimental data to validate analytical models and to evaluate advanced component concepts emanating from the propulsion research and technology base program. Extensive instrumentation will be installed on the first engine assembly in order to experimentally establish a data base which characterizes the internal dynamic environment of these types of engines. Research quality instrumentation capable of accurately measuring both transient and steady-state pressures, temperatures, flow rates, stresses and strains is being provided as it becomes available from the research and technology base program. The data will be used to validate computer codes that have been developed to simulate these dynamic environments and their effect on operating components. In later engine assemblies, advanced technology components designed for extended life and/or higher performance will be evaluated under engine system operating conditions. Advanced turbine blade materials and coatings, damping seals, and advanced longer life bearing designs that have been evaluated initially in rig testing under the research and technology base program are examples of some of the earlier advanced component hardware that will be installed in the engine for testbed verification testing. In addition, advanced sensors being developed and evaluated in test rigs under the research and technology base program for monitoring the wear of high wear rate components will also be installed in engine components for system level test evaluation. These efforts will lead to the eventual assembly and test of a complete engine condition monitoring system.

The testbed engine provides the lowest risk path for verifying the behavior of improvements from the research and technology base program. Many promising products are emerging from the base program that will be ready for testbed engine testing in the FY 1988-1990 time frame. The testbed engine program will provide the experimental tools needed to evaluate longer term, higher risk technology items that will lay the foundation for advanced high-performance reusable engines essential for the support of national transportation needs being identified in current national security directive studies. The Office of Aeronautics and Space Technology portion of this program funds the analyses, design and fabrication of advanced technology components that have been identified as ready and needed for testbed evaluation. The Office of Space Flight funds are used to acquire engine component hardware, to install advanced technology items in the component hardware, to assemble the testbed, and to conduct test operations.

The design and fabrication of research instrumentation and advanced technology components are scheduled to be compatible with the availability of the SI-C test stand at the Marshall Space Flight Center and engine hardware being acquired by the Office of Space Flight for testing starting in FY 1988.

BASIS OF FY 1987 ESTIMATE

The design and fabrication of research instrumentation to be installed on the initial instrumented engine includes high-response pressure and temperature sensors and nonmoving parts cryogenic flow meters. Advanced technology items being designed and fabricated for installation in later engine builds include fiber-optic deflectometer bearing-wear sensors, turbine temperature sensors based on fiber-optic pyrometer concepts, advanced single-crystal turbine blades, thermal barrier coated turbine blades, advanced damping seal configurations, and longer life bearing designs.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Space flight systems technology				
Space flight experiments............	5,342	6,200	6,200	---
Long duration exposure facility.....	700	---	---	---
Ion auxiliary propulsion system.....	600	---	---	---
Total...............................	6,642	6,200	6,200	---

OBJECTIVES AND STATUS

The objective of the space flight systems technology program is to conduct research in space, capitalizing on the use of the space shuttle, spacelab, and free-flying vehicles where it is impossible or too costly to simulate the space environment in ground laboratories. The space environment uniquely provides long-term zero gravity and the combination of space vacuum and space radiation environments necessary to the development and characterization of many technologies important to future space systems. This program encompasses the design, development, and flight test of experiments and the development of special purpose, reusable, flight research facilities for use in space. Beginning in FY 1987, in-space experiments and the space technology experiments platform will be budgeted within the research and technology base. Also, beginning in FY 1987, flight experiments conducted for the control of flexible structures in space will be budgeted within the control of flexible structures flight experiment systems technology program.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Control of flexible structures flight experiment.........................	---	5,000	5,000	11,300

OBJECTIVES AND STATUS

The objective of the control of flexible structures (COFS) program is to provide experimental validation of analytical methods for predicting coupled structural dynamics and controls response for complex multibody space structures with flexible components, interfaces, and dissipative mechanisms. As the agency initiates planning and implementation for large space systems (space station/platforms/antennas), there are basic unknowns in the areas of structural dynamics, controls, structural interaction, structural performance, and deployment dynamics which must be resolved in order to develop this new class of spacecraft with the assurance of meeting safety, performance, and cost goals. The size and flexibility of these systems require a ground research program, including analysis and test methods, and a space-based experiment activity addressing the key technology unknowns through graduated testing of flexible elements of large space structures. This program will provide a validated technology data base that will enable these next generations of large flexible spacecraft to be developed. The research data base will allow the design and development of integrated complex control systems and structural configurations for difficult advanced mission goals to be achieved.

In order to meet the requirements of the control of flexible structures program, a comprehensive research activity which includes analytical methods development, ground-based testing, and in-space experiments was initiated in 1985 to provide a focus for control structures interactive technology.

The space shuttle provides the opportunity to test and validate in space the dynamics, controls, structural concepts, theories, and system components required by future large space structures missions. An in-space experiment program is planned building progressively from modeling and dynamic characterization of large space structures to more complex flexible-body interactive controls/structure issues. The approach provides for structural dynamic functional complexity in a baseline configuration, through the design of a generic flight test article that addresses fundamental large space systems (LSS) discipline issues. These critical issues will include flexible structural configurations that have fundamental frequencies below one hertz, complex nonlinear joint effects, structural dynamic/control systems interactions, and inherent low structural damping effects. This model can be tailored to validate discipline research objectives addressing the major concerns of LSS spacecraft, independent of any specific configurations ultimately chosen for new missions.

The first flight article, COFS I, is a large (60-meter) deployable/stowable truss-beam structure (termed mast) which will be flown in space cantilevered from the orbiter. Actuators and instrumentation necessary for excitation, measurement, and control of the low-frequency modes of mast are an integral part of the mast flight experiment. The mast test article will be mounted on the space technology experiments platform, integrated with the orbiter, and transported to space. Specific objectives of the COFS I flight experiment are to determine the degree to which analytical methodology and ground testing can predict flight performance of next-generation, low-frequency structures; evaluate mathematical modeling of large, lightweight, complex systems; evaluate control/structure interactions; evaluate sensor/measurement techniques applicable to low-frequency systems with low motion/deflection tolerances; evaluate deployment kinematics in zero gravity (g) versus one g; evaluate damping effects in zero g; and evaluate LSS control laws and control mechanizations.

The second flight article, COFS II, will incorporate gimbals and an antenna-like appendage to the COFS I mast hardware and will provide the opportunity to study the more complex structural dynamics and control characteristics of large, flexible, three-dimensional spacecraft configurations. Technology needs that will be addressed by COFS II include maneuver control, articulation, printing, shape control, alignment, systems identification, deployment dynamics, and adaptive controls.

A third activity, COFS III, will be focused on the validation of control-structure interactive analysis and design methodologies for multibody spacecraft. Scale model investigations will be conducted on future large space platforms to determine modeling sensitivities, vibration suppression techniques, appropriate ground test methods, and capabilities.

In FY 1986, fabrication of the COFS I flight article will be initiated, and scale model "mini-mast" testing will begin. In FY 1986, a COFS II project plan will be developed, and the request for bids for the COFS II flight test article will be developed. Also in FY 1986, a COFS III project plan will be developed to support fundamental research and technology development in multibody dynamics and control.

BASIS OF FY 1987 ESTIMATE

Ground-based experiments initiated earlier will be continued in FY 1987 to accurately characterize/synthesize the dynamic behavior of the structure and to develop control laws and methods to control its configuration and motion. Additional analysis and ground-based experiments will focus on expanding the newly developed technology for application to more complex multibody and three-dimensional structures. The preliminary design review and the critical design review of the mast flight test article will be completed in FY 1986. Flight test article delivery will occur at the end of FY 1988. The characteristics of the mast truss-beam flight test article will be defined through initiation of a mathematical model to be validated later in the ground-based and then space test program beginning in FY 1989. In FY 1987, a COFS II program plan will continue with flight article definition. Planning for COFS II will begin with definition of a generic configuration for an antenna-like structure and a related ground test program plan. In FY 1987, the fabrication and testing of scale models of large multibody spacecraft will be initiated.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Orbital transfer vehicle technologies				
Aeroassist technology...............	---	1,500	---	---
Propulsion technology...............	---	1,500	---	---
Total...............................	---	3,000	---	---

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $3.0 million in OTV technologies reflects the transfer of the aeroassist portion of the program to space flight research and technology and the transfer of the propulsion technology portion to propulsion research and technology within the research and technology base.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Automation and robotics technology....	(8,200)	(10,200)	10,200	18,000

OBJECTIVES AND STATUS

The objective of the automation and robotics technology program is to exploit the potential of artificial intelligence and of telerobotics to decrease the cost of ground control and to increase the capability and flexibility of space operations. Artificial intelligence will be used to reduce the size of ground control and operations, and telerobotics will be used to enable increased capability in space servicing, assembly, and repair. The goals of the program are to decrease mission operations manpower by 60 percent; replace 50 percent of extravehicular activity (EVA) with telerobotics; and enable remote servicing, assembly, and repair.

The program focuses on system autonomy and telerobotics. The objective of the systems autonomy effort is to develop a generic set of software tools for the design of expert systems for increasing automatic and intelligent control of complex dynamic space systems. The objectives of the telerobotics focus are to evolve the level of autonomy of remote operations from teleoperation to robotics and to increase the operational capability of remote manipulation from its current state as a crane on the shuttle orbiter to the capability for on-orbit assembly, servicing and repair, and for planetary exploration.

Integration of advancing technologies in each area, systems autonomy and telerobotics, is described by a sequence of evolutionary ground demonstrations scheduled from 1987 to 1996. In systems autonomy, the initial demonstration (1988) is of a rule-based expert system for control of a single-mission operations subsystem in which reasoning is limited to standard procedures and knowledge of the task world is complete and unambiguous. The second demonstration (1990) will be of a model-based expert system for coordinated control of multiple subsystems, and it will be capable of reasoning about nonstandard procedures and of diagnosis of anticipated failures. The third demonstration (1993) will be of hierarchical control of multiple subsystems and will be capable of reasoning about emergency procedures, planning under uncertainty, and recovery from unanticipated failures. The 1996 demonstration will consist of distributed control of multiple subsystems and will have the capability for fault prediction, real-time replanning, and learning. In telerobotics, the initial demonstration

(1987) will be of a two-armed remote manipulator for satellite module replacement and fluid transfer tasks. Autonomy will be implemented in terms of preplanned sequences of task primitives, e.g., open, close, screw in, etc. The second demonstration (1990) will include automatic acquisition and despin of a spacecraft and servicing it using dexterous cooperative arms, automatic sequence planning, and autonomy at the task element level, e.g., remove panel. The 1993 demonstration will comprise task level (e.g., replace module) commands, automated replanning for error conditions, and automated planning using a computer-assisted design (CAD) data base. The 1996 demonstration will extend to repair tasks involving cutting and fabrication.

Underlying both sequences of demonstrations are five core technology areas: sensing and perception, control execution, task planning and reasoning, operator interface, and system architecture and integration. Integrated plans have been developed for the demonstration sequences, and research is underway in the five core technology areas. Coordination with the Defense Advanced Research Projects Agency (DARPA) assures leverage of relevant technologies being developed under their strategic computing initiative. Intercenter memoranda of agreement have been signed to facilitate the transfer of technology from the technology development centers to the user centers.

In sensing and perception, an intermediate-level computer vision system called PIFEX (programmable image feature extractor) has been developed which can detect hardware edges and vertices. Such a visual system will be necessary to enable autonomous recognition of objects from a well defined data base, as well as autonomous capture and despin of tumbling satellites. In control execution, computer vision and force/torque feedback has been used to automatically guide a pin to a close tolerance hole and insert it. This is necessary for autonomous module insertion when the telerobot is operating under conditions of communications time delay. In operator interface, a six degree-of-freedom force-reflecting controller has been developed. Using this technology, the same controller can be used with a number of different space arms. In task planning, an artificial intelligence planner has been developed which, given a set of goals and a knowledge base of relevant actions, can generate a sequence of actions in a satellite's payload to implement those goals. This capability is the basis for the systems autonomy focus. Ongoing and planned work is to evolve this initial autonomous planning capability to a wider set of applications with a reduced set of constraints. In system architecture and integration, a joint venture with DARPA has been initiated to develop a spaceborne symbolic processor to enable on-orbit execution of artificial intelligence software.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The automation and robotics funding previously budgeted and managed in various programs within the space research and technology base ($10.2 million) has been consolidated into a systems technology program for management visibility.

BASIS OF FY 1987 ESTIMATE

The initial telerobot demonstration will take place in late FY 1987. It will comprise a two-arm telerobot which can perform simple servicing and assembly tasks on cooperative spacecraft using hand and power tools. It will include initial autonomous capability in terms of task primitives such as: open, close, screw in, etc. In FY 1987 the two-armed, fixed-base telerobot, as well as the operator control station and the spacecraft mockup, will be constructed, debugged, and demonstrated.

The initial systems autonomy demonstration will be in final preparation in FY 1987 and will take place early the next year. It will comprise automated control (i.e., an intelligent aide) for a single-mission operations subsystem integrated communications. An expert system for integrated communications control will be developed and debugged for use in the shuttle mission control center at Johnson Space Center. The consoles and programs for demonstrating the expert system using real-time shuttle data in an off-line (parallel) mode to actual subsystem control by human controllers will be developed.

Research and development in each of the five core technology areas will continue. In sensing and perception, the focus will be on multiple-class three-dimensional object recognition and tactile/proximity sensing in order to reduce reliance on the human operator's vision system. In task planning, the emphasis will be on spatial planning of manipulator trajectories and on reasoning about nonstandard procedures in order to reduce reliance on the human operator's cognitive capabilities in task planning. In control execution, telerobot control of flexible manipulators and control of multiple-arm degrees of freedom will be developed to enable telerobot servicing of a wider class of spacecraft and payloads. In operator interface, predictive displays and simulation aids for anticipated failures will be developed to permit the operator to take over when the autonomous system encounters difficulty. In systems architecture and integration, the focus will be on developing techniques for expert systems to control an entire system by coordinating the needs and tasks of a number of subsystems.

BASIS OF FY 1987 FUNDING REQUIREMENT

STANDARDS AND PRACTICES

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Standards and Practices...............	4,900	8,000	8,000	9,200

OBJECTIVES AND STATUS

The objective of the Standards and Practices program is to support NASA's goals through activities in productivity; reliability and quality assurance; maintainability; safety; software assurance; systems engineering; and program practices which reduce program risk, improve product confidence, and encourage good program procedures in the technical execution of NASA programs.

During FY 1985, the Office of the Chief Engineer continued its efforts to improve NASA's software management, assurance, and productivity. Emphasis was directed toward developing validated procedures to ensure the integrity of the systems to be put into service. Non-destructive evaluation (NDE) testing techniques were extended to new materials such as composites. The results of this effort will ensure that material and fabrication specifications can be non-destructively verified and that degradation of materials in use can be quantitatively documented. In FY 1986, work continues on efforts with the NASA Centers and industry in the areas of Computer-Aided Design/Computer-Aided Manufacturing; materials, treatments and processes data bases; integrated circuit product assurance; microcircuit radiation effects evaluations; design and manufacturing standards; aerospace and systems safety related matters; and other activities which support NASA-wide program responsibilities.

BASIS OF FY 1987 ESTIMATE

In support of the goals of NASA, the FY 1987 Standards and Practices program will continue to conduct activities related to its objectives. The increase in funding from the FY 1986 level reflects a broadened NDE program, and an expansion of NASA's Software Management and Assurance Program (SMAP).

The efforts of the SMAP are critical to NASA's ability to economically develop and acquire reliable software to support the more complex, computer driven systems required by its future missions. The objectives of the SMAP are to adapt industry and DOD software solutions to the NASA environment, and to create more effective implementation schemes which take advantage of NASA's existing expertise, communications media, and recent lessons learned. Software standards, specialized software training, distributed software corporate memory data bases, and software guidebooks will be the primary products that will facilitate improved software business practices and software resources sharing by NASA projects. Industry, DOD and NASA achievements in the areas of software acquisition management, reliability engineering, and quality assurance will be monitored and assessed on a continuing basis to ensure that NASA's state of software practices is as close as practical to the emerging state of the art.

The NDE Measurement Assurance Program, currently focused on metals and composites, will be expanded to include electronics and will explore and develop qualitative and quantitative inspection and quality control techniques for microcircuits and semiconductors. New microcircuit technology is approaching one micron-line width and, based on past experience, contamination and particulates will have a major impact on microcircuit reliability. Existing quality control practices, especially process control and screening techniques, are inadequate and too time consuming for new-generation microcircuits, making parts availability a major concern for NASA. Some of the current screening methods, such as Particle Impact Noise Detection (PIND) tests and x-rays, are not effective NDE techniques. This program will develop techniques to accompany the advances in microcircuits, and to replace the outdated process and quality control practices and screening techniques. The program will concentrate on the chip level, but will explore the assemblies as well.

The FY 1987 funds will also continue to provide for special efforts focused on finding solutions to specific technical problems arising from programmatic activities. In addition, overall support is required to continue to ensure that advances in technology, such as microelectronics, robotics, computer automation, and composite fibers, can confidently be qualified for use in NASA programs within a timeframe that is consistent with project needs.

RESEARCH AND DEVELOPMENT

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRACKING AND DATA SYSTEMS — TRACKING AND DATA ADVANCED SYSTEMS

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
	(Thousands of Dollars)				
Advanced systems......................	14,800	16,200	16,200	17,100	RD 16-2
TOTAL............................	14,800	16,200	16,200	17,100	
Distribution of Program Amounts by Installation					
Goddard Space Flight Center...........	4,400	5,100	4,700	5,000	
Jet Propulsion Laboratory.............	10,228	11,100	11,500	12,100	
Ames Research Center..................	24	--	--	--	
Headquarters..........................	148	--	--	--	
TOTAL..........................	14,800	16,200	16,200	17,100	

BASIS OF FY 1987 FUNDING REQUIREMENTS

ADVANCED SYSTEMS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Advanced systems......................	14,800	16,200	16,200	17,100	

OBJECTIVES AND STATUS

The objective of the Advanced Systems Program is to perform studies and provide for the development of tracking and data systems and techniques required to: (1) obtain new and improved tracking and data handling capabilities that will meet the needs of approved missions and near-term new starts; and (2) improve the cost effectiveness and reliability needed for overall support of the total mix of spaceflight missions.

As a small but vital portion of the total Space Tracking and Data Systems Program, this activity continues to be focused on assessing and making use of the dramatic changes taking place in the state of the art in telecommunications, electronic micro-circuitry and computer technology. Such effort is critical for proper planning and for the application of cost effective and reliable new technology to future support capabilities. Ongoing work includes the investigation of upcoming missions and studies of ground systems and telecommunication links to determine design approaches and overall tradeoffs for the lowest life cycle costs to support future space missions.

BASIS OF FY 1987 ESTIMATE

Activities planned for FY 1987 include efforts aimed at obtaining location accuracies to the one meter level for Earth-orbiting spacecraft which would make possible a new class of high precision Earth observatory missions on the Shuttle, Space Station and on free-flying spacecraft. The techniques to be studied include a specialized use of the Department of Defense's Global Positioning System and Very Long Baseline Interferometry. Work will also continue on the development of extremely precise radiometric techniques for determining angular direction of future planetary missions to an accuracy of five nano-radians. Such improvements typically lead to improved spacecraft navigation and the conduct of science experiments not previously possible.

New methods for improving communications with spacecraft will continue in such areas as signal coding; use of millimeter wave frequencies on large diameter antennas; the development of more efficient transmitters; highly reliable, low noise telemetry receivers; and, antenna feed systems capable of multiple frequency operation, i.e., K, X, and S-band. Improving space-to-ground link performance can benefit many future missions by reducing mission costs through reduced spacecraft weight and power requirements or increasing the amount or quality of the data returned. Optical communications technology to meet telecommunications needs beyond the 1990's will also be investigated both for its cost-performance advantages over microwave technology and for its potential in space data relay applications.

Use of high density tape and optical disk storage with automated quality control of data is being investigated to meet future image data processing requirements because the data handled from Earth-orbital missions is expected to increase from a current peak of 50 megabits per second to the TDRSS design limit of 300 megabits per second. These future requirements result from high resolution sensors such as multispectral scanners and synthetic aperture radars. New techniques and systems will be developed for the transfer and processing of these high data rates. These developments include a K-band terminal for TDRSS user spacecraft, computer assisted operations, digital processing of high volume data, improved man-machine interfaces, and wide band satellite communications to distribute data to processing centers and users.

Investigations will continue on methods for reducing projected manpower requirements for operating the mission control facilities and for providing the necessary real time interaction between the spacecraft experimenters and their experiments. Other investigations are being carried out in the areas of automated mission control, greater use of distributed command terminals and the performance of orbit and attitude computations on board the spacecraft.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1987 ESTIMATES

GENERAL STATEMENT

The objective of the National Aeronautics and Space Administration program of space flight, control and data communications is to provide for the operational activities of the Space Transportation System and tracking and communication system support to all NASA flight projects. This objective is achieved through the following elements:

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY: A program to provide a cost effective shuttle system with a minimum flight rate capability of 24 per year in 1989 by providing the national fleet of Space Shuttle orbiters, main engines, launch site and mission operations control requirements, initial spares, production tooling, and related supporting activities.

SPACE TRANSPORTATION OPERATIONS: A program to provide the standard operational support services for the Space Shuttle and the expendable launch vehicles. Within Shuttle operations, external tank and solid rocket booster flight hardware is produced; operational spare hardware is provisioned, overhauled and repaired; and manpower, propellants, and other materials are furnished to conduct both flight and ground (launch and landing) operations.

SPACE AND GROUND NETWORK, COMMUNICATIONS AND DATA SYSTEMS: A program to provide vital tracking, telemetry, command, and data acquisition support to meet the requirements of all NASA flight projects. This support is currently provided by a worldwide network of NASA electronic ground stations interconnected by a communications system using ground, undersea, and satellite circuits. In 1986, the Tracking and Data Relay Satellite Systems (TDRSS) will become the primary system for supporting upcoming Earth orbiting missions.

NATIONAL AERONAUTICS AND SPACE ADMININSTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS
FY 1987 BUDGET ESTIMATES

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY	1,484,500	976,500	971,600	745,400
SPACE TRANSPORTATION OPERATIONS	1,314,000	1,725,100	1,725,000	1,524,700
SPACE AND GROUND NETWORKS, COMMUNICATION AND DATA SYSTEMS	795,700	808,300	701,300	798,900
TOTAL	3,594,200	3,509,900	3,397,900	3,069,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

For necessary expenses, not otherwise provided for; in support of space flight, spacecraft control and communications activities of the National Aeronautics and Space Administration, including operations, production, services, minor construction, maintenance, repair, rehabilitation, and modification of real and personal property; tracking and data relay satellite services as authorized by law; purchase, hire, maintenance and operation of other than administrative aircraft; [$3,397,900,000] *$1,069,000,000*, to remain available until September 30, [1987] *1988. (Department of Housing and Urban Development-Independent Agencies Appropriations Act, 1986; additional authorizing legislation to be proposed.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Space Flight, Control and Data Communications

Reimbursable Summary
(In thousands of dollars)

Space Flight, Control and Data Communications	Budget Plan		
	FY 1985	FY 1986	FY 1987
Shuttle Production and Capability Development..................	319,185	317,992	230,000
Space Transportation Operations................................	480,600	300,000	704,000
Expendable Launch Vehicles.....................................	129,582	271,679	77,300
Tracking and Data Acquisition..................................	46,833	45,329	33,000
Total..	976,200	935,000	1,044,300

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1987 ESTIMATES

SUMMARY OF BUDGET PLAN BY SUBFUNCTION
(In thousands of dollars)

Code		FY 1985	FY 1986	FY 1987
253	Space Flight..	2,798,500	2,696,600	2,270,100
255	Supporting Space Activities.........................	795,700	701,300	798,900
	Total, General Science, Space and Technology......	3,594,200	3,397,900	3,069,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1987 ESTIMATES

DISTRIBUTION OF SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS BUDGET PLAN BY INSTALLATION AND FISCAL YEAR

(Thousands of Dollars)

Program		Total	Johnson Space Center	Kennedy Space Center	Marshall Space Flight Center	National Space Technology Laboratories	Goddard Space Flight Center	Jet Propulsion Laboratory	Ames Research Center	Langley Research Center	Lewis Research Center	NASA Headquarters
Space Transportation Systems	1985	2,798,500	1,159,500	383,100	1,205,800	6,300	1,700	2,600	3,800	100	3,400	32,200
	1986	2,696,600	918,930	407,200	1,229,000	8,300	1,400	300	4,900	100	3,000	123,500
	1987	2,270,100	560,500	485,800	1,058,400	8,600	1,200	1,500	2,800	100	500	150,700
Shuttle Production and Capability Development	1985	1,484,500	763,800	105,200	581,300	6,300	500	2,600	—	—	3,400	21,400
	1986	971,600	379,100	64,000	416,000	7,500	—	300	—	—	3,000	101,700
	1987	745,400	210,500	105,500	318,500	7,900	—	1,500	—	—	500	101,000
Space Transportation Operations	1985	1,314,000	395,700	277,900	624,,500	—	1,200	—	3,800	100	—	10,800
	1986	1,725,000	539,800	343,200	813,000	800	1,400	—	4,900	100	—	21,800
	1987	1,524,700	350,000	380,300	739,900	700	1,200	—	2,800	100	—	49,700
Tracking and Data Acquisition	1985	795,700	150	—	17,687	—	429,446	108,402	8,545	—	—	231,470
	1986	701,300	—	—	29,200	—	365,200	122,200	10,900	—	—	173,800
	1987	798,900	—	—	29,300	—	377,200	128,200	12,000	—	—	252,200
Total	1985	3,594,200	1,159,650	383,100	1,223,487	6,300	431,146	111,002	12,345	100	3,400	263,670
	1986	3,397,900	918,900	407,200	1,258,200	8,300	366,600	122,500	15,800	100	3,000	297,300
	1987	3,069,000	560,500	485,800	1,087,700	8,600	378,400	129,700	14,800	100	500	402,900

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE FLIGHT — SPACE TRANSPORTATION SYSTEM PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
	(Thousands of Dollars)				
Shuttle production and operational capability	1,484,500	976,500	971,600	745,400	SF 1-1
Space transportation operations	1,314,000	1,725,100	1,725,000	1,524,700	SF 2-1
Total	2,798,500	2,701,600	2,696,600	2,270,100	

Distribution of Program Amounts By Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Johnson Space Center	1,159,500	910,100	918,900	560,500
Kennedy Space Center	383,100	375,500	407,200	485,800
Marshall Space Flight Center	1,205,800	1,245,900	1,229,000	1,058,400
National Space Technology Lab	6,300	7,200	8,300	8,600
Goddard Space Flight Center	1,700	1,100	1,400	1,200
Jet Propulsion Laboratory	2,600	---	300	1,500
Lewis Research Center	3,400	---	3,000	500
Langley Research Center	100	100	100	100
Ames Research Center	3,800	3,100	4,900	2,800
Headquarters	32,200	158,600	123,500	150,700
Total	2,798,500	2,701,600	2,696,600	2,270,100

PROGRAM OBJECTIVES

The Space Shuttle is the key element of a versatile Space Transportation System (STS) that is available to a wide variety of national and international users. The Space Shuttle is the first reusable space vehicle and is configured to carry many different types of space apparatus, scientific experiments, and national security payloads. In addition to transporting materials, equipment and spacecraft to orbit, the Shuttle offers unique capabilities that cannot be achieved with expendable launch vehicles (ELV)--to retrieve payloads from orbit for reuse; to service and repair satellites in space; to transport to orbit, operate, and return space laboratories; and to perform rescue missions.

Shuttle Production and Operational Capability provides for the national fleet of four Shuttle orbiters, including main engines, and provides for the launch site facilities, initial spares, production tooling, and related supporting activities to meet the needs of NASA, the Department of Defense (DOD), and other domestic and international users of space. This line item contains orbiter production for flight hardware improvements and mission kits; the procurement of a spares inventory for the operational orbiter fleet, including major structural orbiter components; the residual development tasks for the orbiter, Space Shuttle main engine (SSME), external tank (ET), and solid rocket booster (SRB); Johnson Space Center (JSC) mission operations capability development; the equipment provisioning of the facilities for launch and landing at the Kennedy Space Center (KSC); the development of the filament wound case (FWC) solid rocket booster; the initial lay-in of spares and ground support equipment; and the rate tooling for the ET and SRB. Modification of two orbiters, two mobile launch platforms (MLP) and both launch pads for the conduct of the planetary missions (Galileo and Ulysses) in 1986, using the Centaur as an STS upper stage, are also funded under this budget item.

Shuttle Operations provides the standard operational support services for Shuttle, the primary U.S. launch system. Within Shuttle Operations, flight hardware is produced, refurbished and repaired; and manpower, propellants, and other materials are furnished to conduct and support both flight and ground operations. The Shuttle Operations program provides for the launch of NASA missions and on a reimbursable basis DOD, other U.S. Government, commercial, and international missions. The launch schedule calls for 14 flights, including the first launch from the west coast, in FY 1986, 17 flights in FY 1987, and 18 flights in FY 1988. The flight rate is planned to reach 24 launches per year by 1989.

The Shuttle provides launch services to non-NASA users on a reimbursable basis as determined by the greater of each payload's length or weight. Launches occcurring in the current pricing phase (FY 1986 through FY 1988) are priced at $71.0 million (1982 dollars) for commercial launches and $55.5 million (1982 dollars) for DOD launches. Commercial launches occurring subsequent to FY 1988 are to be priced through auction procedures at a minimum of $74.0 million (FY 1982 dollars) in accordance with National Security Decision Directive 181 of July 30, 1985. DOD launches in the FY 1989 through FY 1991 period are priced at $60.0 million (FY 1982 dollars).

The ELV program is now totally funded through reimbursements from users. Privatization of these systems continues to be actively pursued.

STATUS

In orbiter production, the delivery of Atlantis (OV-104) in April 1985 and Columbia's (OV-102) completion of modification and delivery in July 1985 brings to four the number of vehicles available for flight. The emphasis on the orbiter logistics program is ongoing with analysis and procurement activity for the provisioning of orbiter spares for the initial lay-in at the launch site. The procurement of structural spares is also progressing. This program will provide major structural spares for the four orbiter fleet and includes elements such as wings, mid-fuselage, and payload bay doors. Operations spares support the flight program with repairs, procurement of consumables, and replenishment of inventory. Orbiter flight anomalies are resolved under the sustaining engineering effort and support to the launch site contractor is provided through the launch support services contract.

At KSC, activation and equipping of facilities is provided under the launch site equipment budget to support simultaneous processing of Shuttle vehicles to meet the increasing flight rate. Simultaneous processing of flight hardware is currently underway with two mobile launch platforms, two orbiter processing facilities, and parallel processing bays in the vehicle assembly building. The second launch pad, which will also support simultaneous processing and checkout of mated launch vehicles has met its operational readiness date of January 1986 in order to support the two planetary missions, Galileo and Ulysses, in May 1986. In addition, the third mobile launch platform is on schedule for a September 1986 operational readiness date and work continues on outfitting the Orbiter Maintenance and Refurbishment Facility (OMRF) to come on line late in 1986.

At JSC, the third Shuttle training aircraft (STA) has been put into service, while training capacity is being expanded by modification of the simulators and the mission control center. Contingency abort sites will be brought to full operational capability during FY 1986 and FY 1987. Initial efforts are underway on the replacement and refurbishment of JSC mission support equipment.

Development and life certification of the SSME is continuing in support of the flight and ground test program. Design modifications on the high pressure pumps and the hot gas manifold are a continuation of work begun in FY 1983, and are directed at reducing the SSME operating costs, increasing the SSME operating margins, and determining the hardware life and replacement requirements through a certification extension test program. The operating cost reduction activities are concentrated on the high pressure oxygen and hydrogen pumps. The testing of design modifications to the two pumps is well underway and has shown good progress toward improving pump life. These modified design pumps are expected to complete certification testing in March 1986, and will be phased into the flight program beginning in mid FY-1986. Redesign of the hot gas manifold is continuing with the design goal of improving flow conditions which will extend engine life by decreasing systems resistance and reducing pump loads. These manifold changes will be introduced into the fleet beginning in FY 1990. The SSME program also includes an advanced engine development effort which will provide alternate sources for SSME-class hardware, will improve the operating margins on selected critical components, and will evaluate technical advances arising from the OAST technology program.

The experience with the solid rocket boosters during early flights indicated the need for design improvements to reduce the damage incurred during booster water impact. Improvements implemented to date have proven to be successful in reducing structural damage although problems remain with water intrusion damage to the thrust vector control (TVC) servo actuators. Design modifications already underway will continue this year to eliminate this problem. Development of a sensor unit to separate the main parachutes at water impact for added diver safety during recovery operations was completed.

The SRB assembly contractor, USBI, started construction of a refurbishment and subassembly facility in FY 1985, with completion scheduled during the last quarter of FY 1986. During FY 1987, assembly operations will be transferred from the vehicle assembly building and Hanger N facilities to the new facility. Procurement of tooling to support a 24 per year flight rate capability will continue through 1987.

Performance of the external tank on all Shuttle flights to date has been excellent. Emphasis continues on sustaining the rate of cost-reduction and achieving increased production capability efforts as the flight rate increases. Manufacturing flow design and processing improvements necessary to achieve reductions in the tank operational costs have been identified and are being implemented. Efforts are also continuing in the ET as in the SRB programs to provide tooling to support a flight rate of 24 flights per year by FY 1989.

The filament wound case is continuing development and qualification testing for flight use for missions requiring increase payload lift capability. The lighter graphite-epoxy filament wound motor cases will provide an additional 4600 pounds of payload capability to the Shuttle. The first launch of the FWC is scheduled from Vandenberg in mid-1986. The development of the FWC was proceeding on schedule until the recent structural test article (STA) failure. This will require repeating the test to demonstrate adequate margin of safety at engine ignition. The test is scheduled for February 1986 and will support the first Vandenberg launch in mid-1986.

The Shuttle Operations budget provides funding in three principal areas: flight operations, flight hardware, and launch and landing operations. Flight operations includes training, mission control, flight operations planning, payload and systems analytical integration, mission analysis, post-flight anomaly resolution, sustaining engineering and launch support services. A consolidated operations contract covering most of the flight operation functions performed at JSC has been awarded, and the contractor will begin early in 1986.

Flight hardware includes the procurement of orbiter flight spares, SRB rate gyros, ET's and the interface hardware with the orbiter, solid rocket motors and booster hardware, and propellants; engineering and logistics support for external tank/solid rocket booster/main engine hardware elements; and, maintenance and operation of flight crew equipment. A consolidated operations contract covering most of the crew equipment support at JSC will begin transitioning functions during 1986. The funding requested for the ET and solid rocket motors and boosters (including production of filament wound cases) includes long lead time raw materials, subassemblies, and subsystems required to sustain production.

The launch and landing operations budget provides funding for processing of the elements of flight hardware that comprise the Shuttle launch vehicles as they flow through the ground processing stations at KSC. The Shuttle processing contractor (SPC), in conjunction with the base operations contactor (BOC), successfully processed and launched eight operational flights and their associated payloads with two orbiters, Discovery and Challenger, during FY 1985. In addition, Atlantis was delivered to KSC and processed for its first launch, which occurred on October 3, 1985 (FY 1986). Columbia, which had been undergoing structural and thermal protection system modifications at Palmdale, California, was also delivered to KSC in FY 1985 and completed its seventh mission in January 1986. Discovery is scheduled for the first launch from the Vandenberg launch site in 1986. A significant portion of the pre-launch processing will be accomplished at KSC facilities prior to being delivered to Vandenberg, where mating and final pre-launch checkout will be conducted. KSC planning includes launch of 13 flights in FY 1986 which includes back-to-back launches of two planetary missions involving the Centaur upper stage and also the processing of Discovery again for its second launch from Vandenberg.

BASIS OF FY 1987 FUNDING REQUIREMENT

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
	(Thousands of Dollars)				
Orbiter..............................	674,200	333,600	333,600	211,000	SF 1-4
Launch and mission support............	218,100	163,900	169,000	161,000	SF 1-6
Propulsion systems....................	592,200	454,000	454,000	338,400	SF 1-9
Changes and system upgrading..........	---	25,000	15,000	35,000	SF 1-12
Total.............................	1,484,500	976,500	971,600	745,400	

Distribution of Program Amounts by Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Johnson Space Center..................	763,800	371,400	379,100	210,500
Kennedy Space Center..................	105,200	56,700	64,000	105,500
Marshall Space Flight Center..........	581,300	449,800	416,000	318,500
National Space Technology Laboratories	6,300	7,200	7,500	7,900
Lewis Research Center.................	3,400	---	3,000	500
Goddard Space Flight Center...........	500	---	---	---
Jet Propulsion Laboratory.............	2,600	---	300	1,500
Headquarters..........................	21,400	91,400	101,700	101,000
Total.............................	1,484,500	976,500	971,600	745,400

OBJECTIVES AND STATUS

The objectives of this program are to provide for the completion of a fully capable national fleet of Shuttle orbiters; the development of the propulsion systems; preparation of launch site capabilities; and, the potential changes and upgrading of the Space Transportation System (STS).

The four-orbiter fleet includes Columbia (OV-102), the orbiter vehicle developed and flown on the four test and evaluation flights; Challenger (OV-099), the second flight orbiter, which was fabricated using elements of the structural test article; and, two orbiters - Discovery (OV-103) and Atlantis (OV-104) of a lighter-weight configuration. Modifications to orbiters and the related systems integration analyses for the use of the Centaur and its payloads will be completed during 1986. The budget provides necessary improvements, hardware fixes and mission kits for the orbiter fleet to satisfy flight requirements. The provisioning of orbiter spares is an on-going activity to support the requirements for the initial lay-in of line replaceable units of equipment at the launch site. In addition, the budget provides for the extensive acquisition of orbiter structural spares to support the four-orbiter fleet.

Launch and Mission Support provides for capability to support simultaneous processing of launch vehicles at the Kennedy Space Center (KSC); the additional astronaut training, mission preparation and mission operation capabilities required for higher flight rates; the modifications to the launch site facilities to accommodate the new Centaur upper stage; and, studies and analyses of program level improvements for the operations and management of the STS. The first line of KSC facilities supported the launch processing and checkout of one launch vehicle at a time from landing through launch. The additional processing stations allow for simultaneous processing of orbiters and assorted flight hardware to meet the East Coast launch rate of up to 20 flights per year. A Gulfstream II aircraft has been modified into a third Shuttle training aircraft (STA) to support increased training requirements and to permit the existing two aircraft to be overhauled when structural fatigue considerations make this necessary. The upgrading of the mission control center (MCC), the Shuttle Mission Simulator (SMS) complex, the flight planning and preparation facilities and other data handling systems are necessary to provide a full rate capability for flight operations. Support for the Vandenberg launch site, including provisioning of abort landing facilities, is proceeding.

Propulsion Systems provide for the production of the Space Shuttle main engine (SSME) and the development of the capability to support operational requirements established for the SSME, solid rocket booster (SRB), and external tank (ET). The SSME program includes: production of the main engines necessary to outfit and provide spares for the orbiter fleet, ground testing in support of engine development, and an anomaly resolution capability. The SRB production and capability development activities include: the procurement of tooling and equipment to support a flight rate of

24 flights per year; a minimal level of selected studies to continue investigative, analytical and problem-solving activities; and, the development and initial flight hardware for the filament wound case. In the ET program, the objectives are to improve the manufacturing process and provide manufacturing tooling and equipment to support the 24 per year flight rate. Systems engineering support and SSME testing in the main propulsion test article configuration are both provided in systems support.

Changes and Systems Upgrading provides funding for potential changes and system modifications as well as unanticipated new requirements not covered in the budget estimates for the above activities and other program elements.

BASIS OF FY 1987 FUNDING REQUIREMENT

ORBITER

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Orbiter production....................	318,500	117,000	150,800	82,400
Systems integration..................	50,200	---	---	---
Orbiter spares........................	305,500	216,600	182,800	128,600
Total..............................	674,200	333,600	333,600	211,000

OBJECTIVES AND STATUS

With the delivery of OV-104 (Atlantis) in April 1985 and OV-102 (Columbia) in its operational configuration in July 1985, the number of orbiters available for flight has been increased to four. Orbiter production activities include development and installation of hardware improvements necessary to achieve operational capabilities, reduce operational costs, and meet system requirements including improved on board general purpose computers (GPC), inertial measurement units (IMU) and auxiliary propulsion units (APU). Hardware fixes are being made to the brakes and nose wheel steering to improve landing performance. In addition, necessary mission and modification kits requested for specific flights and payloads are included. Other activities cover flight software development to accommodate hardware changes and mission requirements. The structural spares program initiated in FY 1983 maintains a continued production capability and improves the ability to repair structural elements in the event of damage to one of the four orbiters. Fabrication of these major elements is underway and will continue throughout the year. Structural assemblies include the wings, aft thrust structure, engine compartment, crew module (including the nose and cockpit), mid and aft fuselage sections, payload bay doors, vertical tail, and the orbital maneuvering system pods.

The procurement and fabrication of the orbiter spares inventory to support 24 flights per year is ongoing. A concerted effort has been made to better define the spares requirements and production capability at various vendors. A study is underway to determine logistics depot and maintenance requirements. An interim depot system is being implemented utilizing NASA and contractor facilities while the study is being completed and a long-term configuration identified.

CHANGES FROM FY 1986 BUDGET ESTIMATE

Funding for orbiter production and support activities increased $33.8 million. Additional funding was required for operational improvements including brake fixes, nose wheel steering improvements, improved general purpose computer, auxiliary propulsion unit design fixes, and improvement to the orbiter waste collection systems. Additional increases were the result of software upgrades and the deferral of remote manipulator system work from FY 1985 to FY 1986. Funding for spares decreased $33.8 million, including a $35.0 million reduction in structural spares as the result of a cancellation of the augmentation and restructuring of the basic program implemented during 1985.

BASIS OF FY 1987 ESTIMATE

FY 1987 funding provides for completion of major structural components as spares for the orbiter fleet. These structural components include elements such as wings, vertical stabilizer, crew module, payload bay doors, and aft thrust structure. These items are being assembled into varying stages of completion. Ground support equipment and test hardware are also being provided to support KSC systems. Development efforts will continue on the orbiter system improvements begun in FY 1985 and FY 1986. FY 1987 funding will also be utilized for the continuation and improvement of flight software, the acquisition of navigational aids for the trans-Atlantic abort sites, refurbishment of the remote manipulator system qualification hardware and the development of the upgraded general purpose computer, and the improved inertial measurement unit.

Logistics support to the Shuttle program requires the lay-in of orbiter initial spares and rate spares to meet the buildup to a 24 per year flight rate and for support to ground processing operations as the fleet size and flight rate increase. The funding for orbiter spares covers not only the cost of establishing an inventory of orbiter flight spares and ground support equipment spares, but also the logistics support to analyze requirements and procure these spares. In addition, maintenance test equipment will be designed and procured to support establishment of depot maintenance capabilities.

BASIS OF FY 1987 FUNDING REQUIREMENT

LAUNCH AND MISSION SUPPORT

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1986 Budget Estimate
		(Thousands of Dollars)		
Launch site equipment..................	104,300	56,700	59,700	44,500
Mission support capability............	64,700	64,300	72,800	72,600
Mission operations capability.........	49,100	42,900	36,500	43,900
Total............................	218,100	163,900	169,000	161,000

OBJECTIVES AND STATUS

The first line of facilities at KSC activated during DDT&E supports the launch processing and checkout of an orbiter from landing through launch. A second line of processing stations is being phased in to support parallel launch processing of more than one orbiter through the various work areas. The second high bay of the Orbiter Processing Facility (OPF) and the second mobile launch Platform (MLP) were activated in late FY 1982 to support parallel processing of two orbiters. The second set of high bays in the vehicle assembly building, the software production facility, and the second control room were activated in FY 1983 to enable parallel processing through orbiter - ET mate. An SRB processing and storage facility was activated in FY 1984 to facilitate SRB handling including off-loading of segments from rail cars, segment rotation capability, storage capability for two flight sets (16 segments) and the assembly of SRB aft segments. As a result of the second launch pad's recent activation, parallel processing is possible from the start of OPF flow through launch. A third MLP will be activated in late FY 1986 to help meet the flight rate scheduled in 1987 and beyond. Facility modifications supporting the FY 1986 Centaur launches are nearing completion.

Also under Launch and Mission Support are the necessary investments at JSC to support 24 flights per year. Among these capabilities are the ability to rapidly configure the ground data handling system, encompassing mission planning, simulations, and flight design. This is accomplished through the acquisition of an electronic data network, additional hardware, and refined and expanded software.

Other investments necessary to meet STS program objectives include uprating the Shuttle carrier aircraft (SCA) engines to increase load/ferry range capability and improve the long term supportability. The uprated engines should eliminate the need for an in-flight refueling capability from contingency landing sites. It also includes the hardware deliveries for the extravehicular mobility units (spacesuits), other government furnished crew-related equipment, the upgrade/capability expansion of the mission control center, the service life extension to refurbish all T-38 aircraft, and the ongoing program to replace and refurbish aging and obsolete equipment. The latter incorporates technology advances to solve maintenance and operating problems stemming from outdated hardware and software subsystems that manufacturers can no longer support with spares and viable operating systems. At the same time, the use of this advanced technology will permit more rapid reconfiguration from flight to flight, with considerable improvement in responsiveness to manifest and requirements changes.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The Launch and Mission Support total has increased by $5.1 million since the FY 1986 budget. The launch site equipment increase of $3.0 million is due, in part, to increased costs to complete Pad B and MLP-3 and the addition of a flight readiness firing to support the first launch from Vandenberg in 1986. Also, a safing and deservicing capability has been added to the Orbiter Maintenance and Refurbishment Facility (OMRF) in order to allow orbiter vehicles to proceed directly from landing to the OMRF for modifications and repair as well as the initial post flight checkout. Mission operations capability decreased by $6.4 million primarily due to the slower start up of the JSC equipment replacement and upgrading program. Mission support capability increased $8.5 million due to increased post flight analysis.

BASIS OF FY 1987 ESTIMATE

In FY 1987, the launch site equipment activity includes continued upgrade of the operational intercommunications system connecting all major Shuttle facilities at KSC. The current system, installed for the Apollo program, falls short in reliability and capability to support the planned flight rate and is becoming increasingly difficult to maintain. The new system will use state-of-the-art, digital equipment and will interconnect the facilities with a network of fiber optic cabling. Also, during FY 1987, major components of the launch processing systems will undergo initial stages of replacement. The central data subsystem and the checkout, control and monitoring subsystem currently require high levels of maintenance, computer memory is nearing limits, and some major components of these subsystems are no longer commercially available at reasonable costs. In addition, the OMRF will be completed which will provide the capability for orbiters to undergo initial post-flight checkout immediately after landing without having to interrupt the pre-launch processing underway in the Orbiter Processing Facility. The OMRF is also planned as a dedicated area where orbiter modifications and needed repairs can be conducted outside the normal launch-to-launch processing flow since the Palmdale facility will no longer be equipped for this purpose. Equipment from the orbiter assembly facility at Palmdale compatible with this new facility will be moved to KSC for use in the OMRF. Other efforts contained in the launch site equipment budget include addition of structural modifications to both launch pads to protect the orbiters from rain damage while they are awaiting launch, continued support to contingency landing sites, and completion of the Shuttle inventory management system upgrade (SIMS II).

Mission support capability requirements continue establishing an inventory of crew equipment (principally extravehicular mobility units) to support the 24 per year flight rate capability and post-orbital flight (OFT) testing. STS operations effectiveness work and other support functions continue to support the STS achievement of program-wide requirements including the 24 per year flight rate capability.

Mission operations capability funding in FY 1987 provides for completion of modifications to the fixed and motion base simulators at JSC, initiation of the project to re-engine the SCA, and continuation of the service life extension program of the T-38 training aircraft. FY 1987 funding also provides for replacement of obsolete and inefficient equipment in the mission control center and the Shuttle mission simulator.

BASIS OF FY 1987 FUNDING REQUIREMENT

PROPULSION SYSTEMS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Main engine...........................	419,000	357,600	336,200	293,200
Solid rocket booster..................	105,100	43,000	51,700	17,600
External tank.........................	60,500	53,300	63,800	27,600
Systems support.......................	7,600	100	2,300	---
Total.................................	592,200	454,000	454,000	338,400

OBJECTIVES AND STATUS

Propulsion Systems provides for the production of the Space Shuttle main engines (SSME) and the implementation of the capability to support operational requirements established for the SSME, solid rocket booster (SRB), and external tank (ET). The SSME program includes the production of the main engines required for the orbiter fleet, the procurement of spares, ground testing operations development and certification activities to improve operating margins, reliability and durability, and anomaly resolution capability. The SRB program includes the development and qualification of the filament wound case (FWC) solid rocket motors, redesign of the hardware for reusability and operational cost reductions, and procurement of manufacturing tooling and equipment to support fabrication and transportation at the 24 per year flight rate. In the ET program, the objective is establishing the manufacturing capability, primarily tooling equipment and process improvements, to support the 24 per year flight rate. Systems support primarily provides for the testing of the SSME in the main propulsion test article configuration in addition to providing systems integration engineering support.

The main engines continued their record of excellent flight performance during the eight 1985 flights of the Shuttle. Engine performance was nominal during all flights except for a premature engine shutdown on STS-51F resulting from instrumentation failure. The total SSME ground test experience now exceeds 1,264 tests, totaling approximately 258,000 seconds of test time. This experience includes 240 tests, exceeding 51,000 seconds of operation, at the full power level (FPL).

During the course of FPL testing over the past several years, it became apparent that design margins were inadequate for routine FPL flight operation and that the current SSME configuration required an unacceptable amount of maintenance at that power level. Consequently, the SSME program was restructured into three areas: (1) flight support, (2) product improvement and (3) advanced development.

The flight support element, involving both production and operations, is charged with producing all engine hardware, conducting the acceptance and flight anomaly resolution tests which are directly related to the flight program, providing all logistics support (including engine/component overhauls), and conducting the flight readiness assessments.

The product improvement element continues the work begun in FY 1983 to reduce the SSME operating costs and increase the SSME operating margins. Work to reduce the operating costs is concentrated in design modifications to the high pressure oxygen and hydrogen pumps. The testing of the modifications to the two pumps is well underway and has shown good progress toward achieving better pump life. Modified design pumps are expected to complete certification testing in March 1986 and will be phased into the fleet beginning in mid FY 1986. A redesign of the hot gas manifold is underway to provide better flow conditions, and hence lower resistance and lower pump loads. These manifold changes will be available for test in FY 1986 and for subsequent introduction into the fleet beginning in FY 1990 during routine engine overhauls.

The objective of the advanced development element is to assure a viable technology program for the development of SSME class rocket engines, (i.e., high thrust, high performance, cryogenic fuels) and components; to provide an independent means to evaluate the technical advances arising from the supporting research and technology program by means of a technology testbed; and to provide an alternative source for SSME hardware. Contractor selection for the alternative SSME hardware is scheduled to be completed during FY 1986.

The SRM FWC second development motor (DM-7) static test firing was successfully tested in April 1985, and the qualification motor has been processed and is being prepared for static test in mid FY 1986. The structural test article (STA-2A) successfully passed all but the final load test cycles. The test article failed at 118.5% of engine ignition limit loads. Replacement test articles are being prepared for repeating this load cycle in February 1986. The first flight articles delivery to Vandenberg was completed by July 1, 1985 in support of the mid 1986 launch and the Air Force need date.

Transition to the production mode in the ET program is well underway. Production readiness activities continue to smooth this transition and favorably improve production capability. Rearrangement of existing tools and new tools to eliminate manufacturing "choke points" and smooth the production flow for the buildup to 24 tanks per year has been emphasized and is nearing completion.

In systems support, preparations are underway for the test of three clustered engines at full power level in the main propulsion test stand at NSTL in early 1986. This test will provide for a verification of the main propulsion system operations at full power level using the main propulsion system test hardware mounted in the aft end of the simulated orbiter.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease in funding requirements within Propulsion Systems for the main engine project of $21.4 million includes a rephasing of the two elements of the SSME advanced development effort. The start of the competitive program for alternative SSME hardware has been delayed to allow for the contractor selection process which is scheduled for completion in FY 1986. To maintain program balance, the technology test bed has also been rephased. In addition, the decrease in capability development reflects the restructuring of the main engine contract consistent with actual use of spares and flight support. This resulted in the transfer of some flight support and flight hardware to operations. The life improvement program increased in FY 1986 due to increased test requirements.

These decreases were partially offset by the increase of $8.7 million for the SRM project due to development problems experienced on the FWC program and additional residual development tasks on the SRB. ET funding requirements increased $10.5 million as a result of the rephasing from prior years of the rate tooling requirements in accordance with the slower flight rate buildup. The increase in systems support of $2.2 million is attributed to the extension to FY 1986 of the main propulsion test for full power level testing. Following completion of these tests, the main propulsion test stand will be converted to a single engine capability to support the SSME development/production program.

BASIS OF FY 1987 ESTIMATE

In FY 1987, funding for the SSME provides for those activities necessary to support the engine production, flight schedules, and ground testing. Product improvement testing will continue as will certification of new SSME component design modifications. Other on-going activities also provided for within the SSME budget estimates include development and production of the Block II controller, anomaly resolution testing, updating of the SSME hardware to the improved component configuration, and advanced development effort.

In the SRB, efforts will continue on the improvements to the thrust vector control system to prevent salt water intrusion and to provide rate tooling to support the 24 per year flight rate in FY 1989. The construction of the new assembly and refurbishment facility will be completed, and efforts will start on the installation of equipment. Producibility improvements will also continue in order to reduce the turnaround time required for assembly and refurbishment of boosters.

In the ET program, enhancement of manufacturing processes will continue through production readiness efforts. The major thrust for FY 1987 will be continuing procurement and installation of tools and equipment to support the build-up to a production rate of 24 per year.

BASIS OF FY 1987 FUNDING REQUIREMENT

CHANGES AND SYSTEMS UPGRADING

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Changes and systems upgrading........	---	25,000	15,000	35,000

OBJECTIVES AND STATUS

Management, technical flight experience, and cost reviews of the Shuttle program have stressed the need for providing an adequate allowance for changes and modifications which inevitably are required in a large, complex, and technically demanding space system.

The Changes and Systems Upgrading budget represents the estimated requirement for potential changes and systems modifications and unanticipated developments which are not included in the program element budget estimates. Such funds are necessary to provide for programmatic and technical changes, such as modifications to the orbiters to improve flight performance and system reliability, changes and upgrading of ground systems to reduce turnaround time between missions, and replacement/modification of hardware elements to achieve increased operating economies.

As the changes and upgrading requirements are identified and approved, the remaining FY 1986 funds will be allocated to the appropriate budget activity.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The FY 1986 operating plan has allocated $10 million of Changes and Systems Upgrading. Within this total, $5 million was allocated to support increased requirements in Launch and Mission Support and $5 million was deleted as an application of the HUD-Independent Agencies Appropriation Act, 1986. General reduction for Space Flight, Control and Data Communications is consistent with direction in the FY 1986 Authorization Act.

BASIS OF FY 1987 ESTIMATE

The funding requested for FY 1987 will provide for those changes which are considered to have the highest priority. The objectives are to improve reliability, increase operating efficiency, and reduce costs. Changes and upgrading areas of interest include modifications to flight and ground systems; design and development of hardware/software systems which meet requirements for improved safety, reliability, performance and cost-effectiveness; and changes which will reduce operational costs by extending operational life, by facilitating improved mission-to-mission turnaround time, and by improving mission performance margins. Change requirements are expected to increase in FY 1987 as operational experience is gained with the doubling of the FY 1985 flight rate to 17 in FY 1987, with the initial experience of utilizing capabilities such as the Centaur upper stage, with initial operations at the Vandenberg launch site, and as the demands of supporting four orbiters in parallel processing are realized.

BASIS OF FY 1987 FUNDING REQUIREMENT

SPACE TRANSPORTATION OPERATIONS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Flight operations..................	315,600	425,200	435,000	360,600	SF 2-3
Flight hardware....................	722,900	964,000	957,600	879,100	SF 2-7
Launch and landing operations.......	275,500	335,900	332,400	285,000	SF 2-9
Total..............................	1,314,000	1,725,100	1,725,000	1,524,700	

Distribution of Program Amounts by Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Johnson Space Center..................	395,700	538,700	539,800	350,000
Kennedy Space Center..................	277,900	318,800	343,200	380,300
Marshall Space Flight Center..........	624,500	796,100	813,000	739,900
National Space Technology Laboratories	---	---	800	700
Goddard Space Flight Center...........	1,200	1,100	1,400	1,200
Langley Research Center...............	100	100	100	100
Ames Research Center..................	3,800	3,100	4,900	2,800
Headquarters..........................	10,800	67,200	21,800	49,700
Total................................	1,314,000	1,725,100	1,725,000	1,524,700

OBJECTIVES AND STATUS

Shuttle Operations direct appropriated funding is combined with the reimbursements for standard service received from other U.S. Government, commercial, and international users to support the launch and flight operations requirements of the Space Shuttle. Through 1985, 19 operational Shuttle missions were successfully flown. These missions demonstrated many of the Shuttle's capabilities including deployments of spacecraft and their upper stages, satellite repairs, satellite retrieval and operations using the remote manipulator, a dedicated Spacelab, extravehicular activity operations, a night landing, and a widening of the Shuttle's performance envelope. In FY 1986, 14 missions are scheduled to be flown, 17 are scheduled for FY 1987, and 18 flights are planned for FY 1988.

The Flight Operations activity is divided into three major elements: mission support, integration, and support. Mission support includes a wide variety of planning activities ranging from operational concepts and techniques to detailed systems operational procedures and checklists. Integration includes launch support services and sustaining engineering for orbiter systems, cargo analytical integration, and systems integration. The support element includes base operational support at JSC and systems activity at JSC, Headquarters, and the Goddard Space Flight Center.

The Flight Hardware program element provides for the procurement of external tanks (ET), solid rocket motors, booster hardware, and propellants; spare components for the Space Shuttle main engine (SSME); orbiter spares; ET disconnect and SRB rate gyros, logistics support for the ET, SRB, and SSME flight hardware elements; and maintenance and operations of flight crew equipment. Included in the funding request for tanks and boosters are the long lead time raw materials, subassemblies, and subsystems necessary to sustain the production of elements in a manner consistent with the increasing flight rate.

Launch and Landing Operations provides for the pre-launch preparation, launch, and landing operations of the Shuttle and its cargo.

The Expendable Launch Vehicle (ELV) program provides for the procurement of expendable launch vehicles and launch support services. The Department of Defense and the National Oceanic and Atmospheric Administration are continuing to utilize the Delta, Scout, Atlas and Atlas Centaur expendable launch vehicles on a fully reimbursable basis. There are no direct appropriated fund requirements for the Expendable Launch Vehicles program. The privatization of these systems continues to be actively pursued.

BASIS OF FY 1987 FUNDING REQUIREMENT

FLIGHT OPERATIONS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Mission support........................	155,500	182,900	197,600	117,000
Integration............................	86,900	126,300	125,300	115,600
Support................................	73,200	116,000	112,100	128,000
Total..................................	315,600	425,200	435,000	360,600

OBJECTIVES AND STATUS

Flight operations is divided into three major areas of activity: mission support, integration and support. Mission support includes a wide variety of planning activities ranging from the development of operational concepts and techniques to detailed systems operational procedures and checklists. Tasks include flight planning, preparation of systems and software handbooks, flight rules, detailed crew activity plans and procedures, development and implementation of the mission control center (MCC) and network system requirements for each flight, and operations input to the planning for the selection and operation of Shuttle payloads. Specific flight planning activity encompasses the flight design, flight analysis, and software activities. Flight design products include conceptual flight profiles and operational flight profiles which are issued for each flight as well as support to the crew training simulations and flight techniques. The software activities include the development, formulation, and verification support of the guidance, targeting, and navigation systems software requirements in the orbiter and MCC. In addition, the flight-dependent data located in the erasable memory (mission-to-mission changes) is developed in the flight design process for incorporation into the orbiter software, Shuttle mission simulator, and MCC systems. Integration includes vehicle, payload and system integration and launch support services. Support includes base operations support to Shuttle operations at JSC and systems level support at JSC, Headquarters, and Goddard. The Space Transportation System operations contract (STSOC), a consolidation of work currently being performed by 16 firms under 22 separate contracts, has been awarded. This contract is an incentive fee contract similar to the SPC at KSC as it is mission oriented with fee determination based on cost management as well as performance. The STSOC contractor will be responsible for major functions of such facilities as the MCC, Shuttle Mission Simulator (SMS), Shuttle Avionics Integration Laboratory (SAIL), Software Production Facility (SPF), and the Mockup and Integration Laboratory (MAIL).

CHANGES FROM FY 1986 BUDGET ESTIMATE

The Flight Operations direct budget requirement increase of $9.8 million reflects the impact of a three equivalent flight reduction for commercial customers in the FY 1985 through FY 1988 timeframe. As a result, the allocation of reimbursements for Flight Operations was reduced $21.9 million. This increase was partially offset by a $12.1 million reduction in total funding requirements including sustaining engineering and the application of program reserve.

BASIS OF FY 1987 ESTIMATE

The Flight Operations portion of the Shuttle Operations budget continues to support that activity predominately associated with the effort at JSC to plan for and conduct the on-orbit portion of STS missions from launch to landing. Included in this activity is the pre-flight planning and mission design necessary to conduct and control a successful mission; maintenance and operation of onboard avionics software and mission control systems; maintenance and operation of the training and flight proficiency aircraft and facilities for crew training; integration of the orbiter, payload, and STS; sustaining engineering for the orbiter and flight operations systems; post flight data analysis and anomaly resolution; and systems-wide management activities required for mature STS operations. During FY 1987, 17 flights will be supported. As a result of the pre-flight planning and integration cycle, FY 1987 activities will include the planning and training for the 18 flights in FY 1988 and the initial phases of the flight design process for the 24 flights in FY 1989.

With implementation of the consolidated STS operations contract (STSOC), there has been a realignment of work among three Flight Operations categories--mission support, integration, and support as described below:

Mission support encompasses all of the STSOC effort funded in Flight Operations, performing the functions directly related to flight preparation and execution. Major items no longer included are spacecraft software (except flight-to-flight reconfiguration), aircraft operations, and the non-STSOC portion of engineering support, notably engineering analyses, materials and subsystem testing, and payload/orbiter operations safety reliability and quality assurance.

The tasks performed by the STSOC contractor include project management, maintenance and operations, sustaining engineering, flight preparation requirements and analysis, flight preparation production, and direct mission operations and training support.

Project management includes the overall management functions of project, resource, configuration, information, and logistics management; plus contract administration, procurement, personnel, security, safety, reliability, and quality assurance.

Maintenance and operations includes contractor maintenance and operations services for the STS major facilities and assets; i.e., mission control center, Software Production Facility, flight operations trainers and crew simulators, Shuttle Avionics Integration Laboratory, and the flight and training planning facilities.

Sustaining engineering includes anomaly investigation, requirements analysis, planning, and feasibility studies, leading to design, development, integration, and testing of improved hardware and software systems. The objectives are to correct system deficiencies, decrease operating/security costs, implement new NASA requirements, and maintain reconfiguration production tools consistent with the flight software for the same systems and facilities for which the contractor has maintenance and operations responsibilies.

Flight preparation requirements and analysis includes engineering and analysis support for the preparation of each STS flight, including flight profile design and analysis; navigation flight preparations; crew activity planning training preparation; systems support analysis; and STS program, payload vehicle and scheduling support.

Flight preparation production includes generating the products required of STS flights as well as postflight products. The work stations included in this process are flight design, flight data file, MCC, Software Production Facility, Trend Monitoring System, Shuttle Mission Simulator, Mockup and Integration Laboratory, and Shuttle Avionics Integration Laboratory. Postflight reconstruction, including the Shuttle Telemetry Conversion Facility and distribution of postflight products, is generated to serve engineering and management needs.

Direct mission operations and training support includes the support to and conduct of all mission training, the flight in real time, and the selected testing related to mission control and supporting operations, SAIL operations support, navigation system quality assessment, and Manipulator Development Facility and 1-G trainer and mockup operations.

Integration now includes spacecraft creation in addition to retaining payload analytical integration, systems integration, orbiter sustaining design engineering, and launch support services, which provides development contractor expertise on-site at the launch site for pre-launch processing. Payload and systems integration assures compatability, safety, and integrity among all flight elements, including the verification of interfaces. Orbiter sustaining design engineering ensures vehicle maintainability, reliability, and provides for anomaly resolution during operations, as well as identification of operational requirements and their design solutions for improved flight systems.

Support continues to include: base operations activities related to Shuttle Operations; the "Getaway Special" payload canister project managed by the Goddard Space Flight Center; Headquarters programs assessments for agency-wide activities; and efforts of the STS Program Office associated achieving program objectives such as the planned flight rate, schedule reliability, and management efficiencies. The major additions to this category are aircraft operations and the non-STSOC portion of engineering support such as engineering systems support furnished by Draper Labs, crew and biosystems laboratories, and the White Sands Test Facility.

BASIS OF FY 1987 FUNDING REQUIREMENT

FLIGHT HARDWARE

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Orbiter	157,300	238,400	257,600	232,700
Solid rocket booster	298,600	401,500	392,700	357,900
External tank	267,000	324,100	307,300	288,500
Total	722,900	964,000	957,600	879,100

OBJECTIVES AND STATUS

The Flight Hardware program element provides for the procurement of external tank (ET) and solid rocket booster (SRB) hardware, and propellants; spare components for the main engine (SSME); orbiter spares including ET disconnects and SRB rate gyros; sustaining engineering and logistics support for ET/SRB/main engine flight hardware elements; and maintenance and operation of flight crew equipment. Included in the funding request for tanks and boosters are the long lead time raw materials, subassemblies, and subsystems necessary to sustain the production of these elements in a manner consistent with the increasing flight rate. Production phasing of these elements is based on the current flight traffic model and is structured to maintain a smooth and efficient buildup of the production capability. In the ET, an efficient and non-disruptive production process continues to be implemented which enables manufacturing, assembly, and checkout operations to proceed on a basis that provides for timely delivery of flight hardware to the launch site. The orbiter line element includes: orbiter spares for replenishment of line and shop replaceable units, the manpower for supporting this logistics operation and the repair capability for flight hardware; SSME overhauls, flight support, and procurement of replacement spare parts; provision for the fixed level of annual support for the liquid hydrogen plant; and, replaceable spares, field support, and maintenance of crew-related equipment. Some examples of orbiter spare equipment are fuel cells, tiles for thermal protection, tape recorders, leading edge support structures, wheels, brakes and pyrotechnics. The crew-related equipment activities include support to the pre-flight training and flight usage of the extravehicular maneuvering unit, emergency portable oxygen systems, radiation instrumentation, survival radios, closed-circuit television cameras, medical support, and food and other galley-related items. The majority of the crew equipment tasks have been consolidated contractually into the Flight Equipment Processing Contract (FEPC). Boeing has been selected as the FEPC contractor and will consolidate the functions previously performed by 16 contractors. Transition to the FEPC will begin during FY 1986.

CHANGES FROM FY 1986 BUDGET ESTIMATE

Direct funding requirements for Flight Hardware show a net decrease of $6.4 million. This includes a $58.6 million decrease in total requirements offset by a $52.2 million increase resulting from reduced commerical reimbursements. The change in total requirements includes decreases in the SRB and ET projects reflecting savings being achieved under current incentive contracts and rephased hardware deliveries for the three flight reduction through FY 1988. The orbiter funding is increased to reflect the restructuring of the main engine contract. This resulted in a transfer from the Shuttle Production and Operational Capability propulsion budget to be consistent with the actual use of spares and flight support.

BASIS OF FY 1987 ESTIMATE

Requirements for orbiter flight spares, crew equipment spares, and logistics are based on calculations involving flight rates, maintenance schedules, operational hours, turnaround times, and lead times to procure or repair flight herware. The budget provides replenishment line and shop replaceable units, as well as the manpower to support the overhaul and repair activity to support the projected and flight rate. Main engine hardware provides for manufacturing and delivery of overhauled engines, engine component spares and flight support. Flight hardware requirements activity for the SRB and ET include the procurement of the materials and labor required for refurbishment and fabrication of units which will be flown after FY 1987, as well as the support of the production of units which will be flown in that year.

BASIS OF FY 1987 FUNDING REQUIREMENT

LAUNCH AND LANDING OPERATIONS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Launch operations.....................	247,300	294,200	292,800	245,800
Payload and launch support...........	28,200	41,700	39,600	39,200
Total..............................	275,500	335,900	332,400	285,000

OBJECTIVES AND STATUS

Launch and Landing Operations provides for the launch preparations and the launch and landing operations of the Shuttle and its cargo. The orbiter, ET, SRB, SSME, and payloads are checked out, integrated, and launched from KSC at Cape Canaveral, Florida. The SRB's are retrieved from the Atlantic Ocean after separation from the Shuttle. Shuttle landing support is furnished at KSC and contingency landing sites as required. The major facilities used for launch and landing operations include: the launch control center, Orbiter Processing Facility, vehicle assembly building, mobile launch platforms, SRB processing and storage facility, payload processing facilities, launch pads, and the Shuttle landing facility.

Funding for Launch and Landing Operations provides the propellants (excluding SRB propellants), manpower and support services required to accomplish the integration and processing of the Shuttle and its payloads. Under launch operations, manpower is provided to process, integrate, and check out the orbiter, ET, solid rocket motors and boosters, and the SSME into the proper launch configuration preparatory to each flight. Support manpower is also included to conduct the SRB retrieval operations, engineering support, logistics, central data system support, facility and equipment modifications, spares procurement and the maintenance and operation of the ground systems, structures and equipment. Funding for payload and launch support provides for the processing and integration of the payloads, propellants for launch operations and base support, and Shuttle landing operations at the Dryden Flight Research Facility.

Contractual arrangements at KSC which consolidate responsiblity and incentives based on performance have provided the framework for achieving a truly operational STS with improved productivity and increased reliability. The KSC base operations contractor has successfully completed its second full year of providing support to Shuttle programs as well as institutional organizations at KSC. The Shuttle processing contract (SPC) is an incentive fee, mission-oriented contract for processing the STS both at KSC and at the Vandenberg launch site (VLS) in California. (The VLS activities are funded by the DOD.) The SPC has completed its second year of operations at KSC and has successfully processed and launched 10 missions, 8 of which were launched in FY 1985. In addition, the SPC initiated processing of the orbiter Discovery in late FY 1985 for its first launch from the VLS in 1986.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The Launch and Landing Operations direct budget requirement decrease of $3.5 million reflects an $18.4 million increase as the result of reduced reimbursement offset by a $21.9 million reduction in total funding requirements. The reduction to total funding includes reduced propellants replenishment from the reduced FY 1985 flights and operational effeciencies.

BASIS OF FY 1987 ESTIMATE

Launch operations funding in FY 1987 provides for manpower and support services necessary for processing the 16 launches from KSC. This includes manpower to process the build-up of the SRB's, mate the boosters and tanks; process the orbiter; mate the orbiter to the integrated SRB's and tank; process and checkout integrated flight elements through launch; retrieve the SRB's for refurbishment; and support landing of the orbiter either at KSC or at a contingency landing site when required. Funding also supports the manpower required for sustaining engineering, spares provisioning, logistics, launch processing system operation and maintenance, and maintenance/modifications of all other Shuttle-related ground support equipment and facilities.

Payload and launch support funding provides propellants for launch operations and base support, and contractor support for the assembly of individual payloads into a total cargo. This element includes providing launch site support managers to payload customers, verifying cargo-to-orbiter interface, and providing operations maintenance and logistic support to cargo support equipment such as cargo integration test equipment and multi-mission payload support equipment and to the payload support areas including the Vertical Processing Facility, operations and checkout building, and cargo hazardous servicing facilities. Support required for maintaining the Dryden Flight Research Facility as a contingency landing site is also included.

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1987 ESTIMATES

BUDGET SUMMARY

OFFICE OF SPACE TRACKING AND DATA SYSTEMS SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS

SUMMARY OF RESOURCES

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate	Page Number
		(Thousands of Dollars)			
Space network.........................	378,300	400,800	286,300	374,300	SF 3-4
Ground networks.......................	233,200	219,300	223,000	222,000	SF 3-9
Communications and data systems.......	184,200	188,200	192,000	202,600	SF 3-18
TOTAL..........................	795,700	808,300	701,300	798,900	

Distribution of Program Amounts by Installation

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Marshall Space Flight Center..........	17,687	27,900	29,200	29,300
Goddard Space Flight Center...........	429,446	365,000	365,200	377,200
Jet Propulsion Laboratory.............	108,402	124,800	122,200	128,200
Ames Research Center..................	8,545	11,000	10,900	12,000
Headquarters..........................	231,470	279,600	173,800	252,200
Johnson Space Center..................	150	---	---	---
TOTAL............................	795,700	808,300	701,300	798,900

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

FISCAL YEAR 1987 ESTIMATES

OFFICE OF SPACE TRACKING AND DATA SYSTEMS **SPACE AND GROUND NETWORKS, COMMUNICATIONS AND DATA SYSTEMS**

PROGRAM OBJECTIVES AND JUSTIFICATION

The purpose of this program is to provide vital tracking, telemetry, command, data acquisition, communications and data processing support to meet the requirements of all NASA flight projects. In addition to NASA flight projects, support is provided on a reimbursable basis for projects of the Department of Defense (DOD), other Government agencies, commercial firms, and other countries and international organizations engaged in space research.

Support is provided for Earth orbital, planetary and solar system exploration missions, research aircraft, sounding rockets and balloons. Included in Earth orbital support are the Space Shuttle, Spacelab flight missions, and Hubble Space Telescope. The various types of support provided include: (a) tracking to determine the position and trajectory of vehicles in space; (b) acquisition of scientific and space applications data from on-board experiments and sensors; (c) acquisition of engineering data on the performance of spacecraft and launch vehicle systems; (d) reception of television transmissions from space vehicles; (e) transmission of commands from ground stations to the spacecraft; (f) communication with astronauts; (g) transfer of information between the various ground facilities and control centers; and (h) processing of data acquired from the launch vehicles and spacecraft. Such support is essential for achieving the scientific objectives of all flight missions, for executing the critical decisions which must be made to assure the success of these flight missions, and in the case of Shuttle missions, to ensure safety of the crew.

Tracking and acquisition of data for the spaceflight projects is presently accomplished through the use of a worldwide network of NASA ground stations, and by the first of a system of three tracking and data relay satellites in geosynchronous orbit working with a single highly specialized ground station. Ground facilities are interconnected by terrestrial and communications satellite circuits which are leased from communications carriers, both domestic and foreign. This interconnection provides the communications capability needed between spacecraft and the control centers from which the flights are directed.

To meet the support requirements levied by the wide variety and large number of flight projects, NASA has established three basic support capabilities to meet the needs of all classes of NASA flight missions. These are the Spaceflight Tracking and Data Network (STDN), which supports Earth orbital missions; the Deep Space Network (DSN), which supports planetary and interplanetary flight missions; and the Space Network including the Tracking and Data Relay Satellite System (TDRSS), which will provide all low Earth orbital mission support when it becomes fully operational.

The STDN will provide Earth orbital support until the TDRSS becomes operational. At that time the STDN phasedown will continue with the closure of six ground stations. This is presently planned for mid-1986 and is based upon the successful launch and checkout of the second TDRSS spacecraft in January, 1986. Two STDN stations (Merritt Island and Bermuda) will be retained to provide prelaunch, launch and Shuttle landing support.

The DSN, under the management of the Jet Propulsion Laboratory (JPL), provides a single network to support geosynchronous, highly elliptical, and planetary and solar system exploration missions, as well as supporting those spacecraft, now in low-Earth orbit, which are not compatible with TDRSS.

Computation facilities are maintained to provide real-time information for mission control and to process into meaningful form the large amounts of scientific, applications, and engineering data which are collected from flight projects. In addition, instrumentation facilities are provided for support of sounding rocket launchings and flight testing of aeronautical research aircraft.

The Space Flight, Control and Data Communications appropriation includes the Space Network, Ground Network, and Data Processing and Communications elements of the program, and provides funds for: (a) the cost of TDRSS service; (b) operations and maintenance of the tracking, data acquisition, mission control, data processing and communications facilities; and (c) the engineering services and procurement of equipment to sustain and modify the various systems to support continuing, new, and changing flight project requirements.

CHANGES FROM FY 1986 BUDGET ESTIMATES

The current estimate for FY 1986 is $701,300 which is $107 million below the budget estimate and represents a reduction in the payment to the Federal Financing Bank (FFB) for the TDRSS consistent with Congressional direction. Within the $701.3 million level, adjustments have been made to provide for the operation of the STDN stations into mid 1986. These and other adjustments are addressed in subsequent sections of the program justification.

BASIS OF FY 1987 FUNDING REQUIREMENTS

SPACE NETWORK

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Tracking and data relay satellite system (TDRSS)	316,600	335,600	218,100	301,500
Space network operations	36,151	37,100	40,500	43,700
Systems engineering and support	25,549	28,100	27,700	29,100
TOTAL	378,300	400,800	286,300	374,300

OBJECTIVES AND STATUS

The Space Network consists of the Tracking and Data Relay Satellite System (TDRSS) and a number of NASA ground elements to provide the necessary tracking, telemetry, command, and communication services to low Earth orbital spacecraft. The TDRSS itself will consist of a three-satellite system, including an on-orbit spare, all in geosynchronous orbit and a single ground terminal located at White Sands, New Mexico. The satellites communicate with the user spacecraft in space and relay information to and from the ground terminal. From the ground terminal, satellite and ground communication links interconnect the NASA elements of the network and any remotely located user facilities.

The FY 1987 request includes funding for: repayment of the loans extended by the Federal Financing Bank (FFB) for TDRSS development; payments to the TDRSS contractor for TDRSS services and for maintenance and operation of the White Sands complex; manpower and services necessary to operate and maintain the other NASA elements of the network; and systems engineering, equipment replacement, engineering analyses and other support activities such as mission planning and documentation.

Funding is also included to continue studies and analyses for assuring the availability of TDRSS support beyond the current TDRSS contract period which ends in 1993. By that time, given the projected TDRS spacecraft lifetimes, the existing TDRS replacement spacecraft will have been launched. In addition, limitations on the present system associated with the ground station at White Sands, New Mexico dictate that a backup capability is urgently needed for that portion of the system. Three additional spacecraft and a second ground terminal will be required to provide TDRSS services through the 1990's.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Tracking and data relay satellite system....................	316,600	335,600	218,100	301,500

OBJECTIVES AND STATUS

The Tracking and Data Relay Satellite System (TDRSS) objective is to provide communication services between the user spacecraft and ground facilities. The Tracking and Data Relay Satellites (TDRS) provide space-to-space communications to and from the user satellites and relay these communications to the ground via a single ground terminal which is interconnected with the other elements of the Space Network. From their position in geosynchronous orbit, the TDRS can provide nearly a six-fold increase in the orbital coverage provided by the existing complex of ground stations and can accommodate extremely high user data rates ranging up to 300 megabits per second.

The TDRS-1 was launched in April 1983, but due to an upper stage failure was delivered to an incorrect orbit. Subsequently, through a sequence of complex maneuvers, the spacecraft was placed into its nominal orbit. Since that time, it has supported Shuttle missions, including Spacelabs, and free flyer missions including Solar Maximum Mission (SMM), Earth Radiation Budget Satellite (ERBS), Landsat, and Solar Mesopheric Explorer (SME). Problems with the spacecraft timing circuitry led to cancellation of the second TDRS launch that was scheduled for early 1985. Modifications have been made to all remaining spacecraft to correct the problem, and the launches of the second and third spacecraft are currently scheduled for January and July 1986, respectively. TDRS-1 will become the on-orbit spare when the two newly launched spacecraft achieve operational status.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The net decrease of $117.5 million includes a $107 million reduction in the payment of principal on the TDRSS loans to the FFB consistent with Congressional direction. The balance of the reduction resulted from adjustments in launch and production schedules due to the delay in the launch of the second and third spacecraft.

BASIS OF FY 1987 ESTIMATE

Under the terms of the TDRSS service contract, loans were extended by the Federal Financing Bank (FFB) to the Space Communication Company (SCC), the owner-operator of the TDRSS, for program development. Under the terms of the loan agreement and assignment, NASA repays these loans directly to the FFB. In addition, NASA will make payments to SCC for TDRSS services for maintenance and operation of the White Sands Ground Terminal and other support to be provided during the year. Current planning provides for launch of the initial four spacecraft using the IUS and the launches of the two subsequent spacecraft using an upper stage to be competitively procured. Activities associated with integrating the fourth TDRS with an upper stage are planned for initiation in FY 1986 and will continue in FY 1987.

Of the amount requested in FY 1987, approximately $227 million is for loan repayments to the FFB for TDRSS development. Approximately $50 million of the request provides for TDRSS service payments, TDRSS integration with an upper stage and other changes and support activities. Another $24 million is included in the request for the maintenance and operation of the White Sands Ground Terminal. These estimates are predicated upon the successful launch and checkout of a second and third spacecraft in 1986.

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Space network operations...............	36,151	37,100	40,500	43,700

OBJECTIVES AND STATUS

The objective of Space Network Operations is to provide for the operation and maintenance of the associated NASA ground systems and facilities which, when combined with TDRSS, provide a full array of reliable tracking, telemetry, command, and communication services to user spacecraft in low-Earth orbit. Each of these NASA elements perform specific functions for the Space Network.

The NASA Ground Terminal (NGT) monitors TDRSS performance, provides fault isolation monitoring for the network, and serves as the communications interface between White Sands and all other facilities. The Network Control Center (NCC) schedules TDRSS services for all user spacecraft, and the Flight Dynamics Facility (FDF) provides orbit determination, trajectory analysis, and position location for flight missions supported by the Space Network and for selected missions supported by the DSN. The Bilateration Ranging Transponder System (BRTS) provides precision position location and orbit determination information for the TDRS. The Simulation Operations Center (SOC) and the Compatibility Test Vans (CTV) provide necessary pre-launch testing, simulations, and interface verification for both user spacecraft and the various network elements to assure the operational readiness of the network to support a given mission.

The individual elements are designed to function as an integrated operational system. Currently, the overall system is providing service to a variety of missions, including Shuttle and Spacelab, as previously noted. Effort is also continuing on achieving an operational configuration that will be capable of supporting an expanded workload in the late 1980's.

CHANGES FROM FY 1986 ESTIMATE

The increase of $3.4 million is necessary to continue to meet the operational support requirements in the Space Network due to the delay of the TDRSS program.

BASIS OF FY 1987 ESTIMATE

The funding request provides for contractor personnel to operate the network systems 24 hours per day, seven days per week, and for the related hardware and software maintenance. Funding also provides for a variety of support activities such as operational analyses, mission planning and documentation. In addition to the missions currently being supported by the Space Network, the support workload will increase significantly in FY 1987 with the launch of the Hubble Space Telescope.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Systems engineering and support.......	25,549	28,100	27,700	29,100

OBJECTIVES AND STATUS

The objective of Systems Engineering and Support is to provide the engineering services and hardware required to sustain and modify the NASA elements of the Space Network. Engineering services are supplied through both the maintenance and operations contract and a number of small, highly specialized engineering service contracts.

Preparations are underway to assure ground system readiness for the two upcoming launches and for full network operation once the total complement of three TDRS's, including the on-orbit spare, are operational. There is also continuing activity to sustain system reliability for current users as well as preparations to meet upcoming support requirements. In the Network Control Center (NCC) display, processing and communication equipment is being replaced and software development is underway to improve TDRSS user access and operational reliability. At the Network Ground Terminal (NGT), there is a continuing effort to automate functions to improve operational reliability and to achieve operating efficiencies. Preliminary effort, associated with the implementation of a second ground terminal for the TDRSS, is also underway.

CHANGES FROM FY 1986 ESTIMATE

The decrease of $.4 million reflects minor reductions in contractor support related to NCC systems engineering.

BASIS OF FY 1987 ESTIMATE

Funds requested will provide for engineering support in the areas of systems engineering, performance and operations analyses, minor facility modifications, network integration testing and interface verification, sustaining engineering support, test equipment, and vendor maintenance for specialized equipment and subsystems within the Space Network. Design and analytical studies will be conducted on a wide array of items ranging from subsystem modifications to meet new mission requirements or to correct system deficiencies to the analysis of the radio frequency environment for potential impact on TDRSS and other network systems. Funds are also requested for continued software development for the NCC and ongoing hardware implementation, replacement and modification.

The FY 1987 funding request will support definition activities which will lead to implementation of a second ground terminal to be located in the vicinity of White Sands, New Mexico. Construction of a second ground terminal will be initiated in 1987 from the CofF appropriation. Experience to date with the existing terminal indicates that to maintain continuity of service over an extended period of time, a backup to the existing White Sands Ground Terminal (WSGT) is essential to eliminate a critical single point of failure in the control and support of space programs.

BASIS FOR FY 1987 FUNDING REQUIREMENTS

GROUND NETWORKS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network systems implementation.......	6,400	2,700	3,000	3,400
Spaceflight tracking and data network operations..................	91,447	58,700	60,400	53,000
Deep space network systems implementation......................	37,100	44,400	44,400	44,000
Deep space network operations.........	77,661	88,900	88,900	94,100
Aeronautics, balloons, and sounding rocket support systems implementation	8,965	11,400	11,400	11,200
Aeronautics, balloons, and sounding rocket support operations............	11,627	13,200	14,900	16,300
Total..............................	233,200	219,300	223,000	222,000

OBJECTIVES AND STATUS

As of January 1, 1986, the Ground Networks included the Spaceflight Tracking and Data Network (STDN), consisting of nine geographically dispersed ground stations which support Earth orbital missions; the Deep Space Network (DSN) consisting of three stations approximately 120 degrees apart in longitude, which support planetary and solar system flight missions and some Earth orbital missions; and instrumentation facilities, both fixed and mobile, which support the Aeronautics, Balloon and Sounding Rocket (AB&SR) programs. In addition, sounding rocket and balloon launches are conducted at selected worldwide locations.

Funding for the ground networks provides for operation and maintenance of the worldwide facilities, as well as engineering and procurement of equipment to sustain and modify network systems. The workload in FY 1987 includes ongoing support to the Space Shuttle, and spacecraft including Voyager, Galileo, Ulysses, Pioneers, Dynamic Explorer, International Ultraviolet Explorer (IUE), Nimbus and the International Sun-Earth Explorers, as well as preparation for support of such upcoming missions as the planned Voyager-Neptune encounter, Magellan (formerly Venus Radar Mapper), and the Mars Observer. Support will also be provided to aircraft programs such as the F-16 and F-111 and the X-29A forward swept wing.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network systems implementation.......	6,400	2,700	3,000	3,400

OBJECTIVES AND STATUS

The Spaceflight Tracking and Data Network (STDN) systems implementation program encompasses the procurement and implementation of services and hardware to sustain network facilities and equipment to ensure reliable tracking, command, and data acquisition support to ongoing scientific and applications satellite missions and the Space Shuttle. The network is currently supporting many missions with highly complex requirements for tracking, data acquisition, command and control including Shuttle and Spacelab missions. With the closure of six STDN ground stations planned for mid-1986, this program will be limited to sustaining capabilities at Bermuda, Merritt Island, Florida and the Wallops Flight Facility.

CHANGES FROM FY 1986 ESTIMATE

The increase of $0.3 million is for sustaining STDN systems and facilities into late FY 1986 due to the delay in the station closure dates.

BASIS OF FY 1987 ESTIMATE

The FY 1987 request includes funds for the replacement of obsolete and difficult-to-maintain equipment at those facilities that remain open after the TDRSS is operational. These facilities will be used for prelaunch, launch and landing support at Bermuda and Merritt Island, Florida, and for limited orbital support from the Wallops Flight Facility for the Space Shuttle. The requirements for support from these sites will continue for the foreseeable future. Equipment replacements and modifications are required in FY 1987 to maintain a level of proficiency to support the continuing workload and to assure the reliability of the major systems. Accordingly, funds are required to replace obsolete equipment, for reliability modifications and to achieve operating efficiencies in the network. The funds requested also provide for procurement of major subsystem spares, for the provision and modification of test equipment, and for minor equipment modifications resulting from changes in support requirements.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Spaceflight tracking and data network operations..................	91,447	58,700	60,400	53,000

OBJECTIVES AND STATUS

The primary function of the Spaceflight Tracking and Data Network (STDN) system is to support NASA Earth-orbital spaceflight missions, including the Space Shuttle. This network also provides launch support to NASA planetary missions, and on a reimbursable basis, spaceflight missions of other United States government agencies (NOAA and DOD) and other nations.

As of January 1, 1966, the STDN consisted of nine geographically dispersed ground stations. Eight of these stations are located at: Greenbelt, Maryland; Merritt Island, Florida; Kauai, Hawaii; Guam; Ascension Island; Dakar, Senegal; Bermuda; and Santiago, Chile. These global facilities have the capability to electronically track the spacecraft, send commands for spacecraft and experiment control purposes, and receive and display engineering and scientific data from the spacecraft. In the case of manned flights, they maintain voice communications for crew operations and safety and other project-related purposes. The ninth station, located at Yarragadee, Australia, provides only air-to-ground voice communication with the astronauts.

During FY 1986, the tracking and data acquisition support function will be transferred from the station at Greenbelt, Maryland to the Wallops Flight Facility in Virginia. When the second TDRS satellite is operational, the following STDN stations will cease operations and be closed: Ascension Island, Guam, Hawaii, Santiago and Yarragadee. Dakar will close about three months later when the third TDRS satellite is on station to support the ascent phase of STS missions. The two remaining stations at Merritt Island and Bermuda will provide prelaunch, launch and STS landing support.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The net increase of $1.7 million results from requirements to operate the STDN stations for nine months in FY 1986 for Shuttle and other support brought about by the delay in the Tracking and Data Relay Satellite launches. The STDN will be required to provide Shuttle and other spacecraft support until the second TDRS is successfully launched and checked out, with the Dakar station being required until the third TDRS is capable of supporting the Shuttle ascent mission phase. An adjustment has been made in this program for the transfer of operations from the Greenbelt, Maryland tracking station to the Wallops Flight Facility in April, 1986.

BASIS OF FY 1987 ESTIMATE

The FY 1987 funding requirements provide for the maintenance and operation of the remaining STDN stations. These estimates are based upon the successful launch and checkout of the second and third TDRS's as currently planned. Included in the funding request are the related logistics support, network planning, scheduling, engineering, documentation and software programming costs associated with the operation of the network stations. Logistics support in the form of spare parts and some equipment repairs is provided to a variety of OSTDS users including the Deep Space Network (DSN), NASA Communications Network (NASCOM), Space Network, Wallops Flight Facility, and project control centers.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Deep space network (DSN) systems implementation...............	37,100	44,400	44,400	44,000

OBJECTIVES AND STATUS

The role of the Deep Space Network (DSN) is to provide the communication link between each of NASA's distant planetary and interplanetary spacecraft and the Earth. The DSN is responsible for receiving science and engineering data and providing the navigation, command and control capabilities from the ground to a wide variety of spacecraft ranging in distance from low earth orbit to over 5.3 billion kilometers from Earth. When the three STDN stations were consolidated with the DSN stations in Australia, California and Spain in February 1985, the DSN also assumed support responsibility for several spacecraft already in Earth orbit and for any spacecraft not supportable by the TDRSS. Several of these support requirements include missions in low-Earth, highly-elliptical and synchronous Earth orbits.

The systems and facilities required to support spacecraft at the limits of the solar system are highly specialized and include the use of large aperture antennas electronically configured in a phased array to receive the extremely weak radio signals. The antennas use ultrasensitive, cryogenically cooled receivers and powerful transmitters. Extremely stable hydrogen maser time standards are required for precise navigation of distant spacecraft. Advanced data handling systems are required at both the DSN complexes and the Network Operations Control Center (NOCC).

Since the Galileo spacecraft is the first to utilize a receiver in the X-band frequency spectrum, the ground network must be implemented to transmit commands in this frequency range. By mid-1987, a 34-meter antenna at Spain and Australia will be implemented with this capability. Not only will Galileo utilize this new frequency for spacecraft telecommunications, but it will also use a new precision tracking capability to perform experiments designed to detect perturbations in the gravity field caused by collapsing quasars. As all new deep space missions will utilize X-band, it is planned to implement this capability on most of the remaining antennas in the DSN by 1992.

The four major objectives for the DSN in the late 1980's are as follows: (1) to provide communications channels to scientific spacecraft at ever-increasing distances and to provide the capability to receive images at these great distances; (2) to increase the frequency range and data rate capability of the ground network to accommodate new spacecraft requirements; (3) to provide support for a new set of spacecraft which will include highly elliptical Earth orbiters and synchronous Earth orbital missions (both types will be in orbits at altitudes that are beyond the support area of TDRSS); and (4) to provide the improved navigation capabilities required for precise spacecraft targeting and probe delivery.

These objectives represent a significant challenge to the DSN, as it will be supporting many more spacecraft than in the past, many of which will be at extremely great distances. The most distant planetary encounter will be of Neptune by Voyager-2 in 1989. This encounter will occur some 4.5 billion kilometers from Earth. At that time, Voyager-2 is expected to transmit the first high resolution images ever received from a spacecraft at such a distance. An expansion of the 64-meter antennas to 70 meters which is underway, along with multiple antenna arraying of radiotelescopes in New Mexico, Japan and Australia, will provide the increased signal capturing capability for the first look at Neptune.

Upcoming missions which will be supported by the network include Galileo, Ulysses, Magellan and Mars Observer.

BASIS OF FY 1987 BUDGET REQUEST

Funding in the FY 1987 request provides for continuing the evolution of the DSN, taking advantage of the latest technologies to meet the increasingly complex support requirements. Included are new capabilities needed to meet the more stringent navigation and spacecraft-ground telecommunications requirements while reducing overall maintenance and operations costs.

Funds are included in the 1987 budget to implement the new capabilities required for the mission. These are: (1) high telemetry data rates which will require telemetry system modifications and (2) spacecraft signal dynamics which will require extensive changes to the receiver system.

The X-band transmission capability required for Galileo will require extensive additions to the new 34-meter antenna feed systems at Spain and Australia and the addition of a transmitter to these antennas which are currently in a "listen only" configuration. Extensive improvements to the ground tracking systems are required in 1987 to provide the navigation accuracy required for the Galileo probe release. This mission event requires that the position of the spacecraft be precisely known in order that the probe, when released, will follow the correct ballistic trajectory into the Jovian atmosphere.

Work will continue in 1987 in preparation for the Voyager 2 spacecraft encounter of the planet Neptune which will occur in 1989. This activity consists of implementation of an X-band receive capability for the Very Large Array at Socorro, New Mexico (which will be arrayed with the Goldstone, California antennas) and the 64-meter antennas at Parkes, Australia and Usuda, Japan (which will be arrayed with the DSN antennas at Canberra, Australia).

To improve the operability, maintainability and reliability of the DSN, significant modifications, including replacement of obsolete equipment, will be made during 1987 at the signal processing centers at the three DSN complexes and at the Network Control Center at Pasadena, California.

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
Deep space network operations.........	77,661	88,900	88,900	94,100

OBJECTIVES AND STATUS

The three Deep Space Network (DSN) complex locations--Goldstone, California; Canberra, Australia; and Madrid, Spain--are approximately 120 degrees apart in longitude to permit continuous viewing of planetary and solar system spacecraft. Each complex has one 64-meter and two 34-meter diameter antennas including one 34-meter antenna under construction at Madrid. A centralized control center for the network is located at the Jet Propulsion Laboratory (JPL) in Pasadena, California. The DSN also operates 26-meter antennas at all three stations having completed the consolidation of STDN station resources under the network consolidation program. These 26-meter antennas are used to track spacecraft in the vicinity of the Earth which cannot utilize TDRSS.

The Voyager-2 spacecraft encounter with Uranus in January 1986 should provide the first detailed information on that distant planet. Voyager-1 is now about 3.8 billion kilometers from Earth on a trajectory that will take it out of the solar system. The Pioneer-10 Spacecraft is now beyond the orbit of Neptune, and is the first man-made object to leave the solar system. It now takes just under ten hours for a radio signal, traveling at the speed of light, to make the round trip between Earth and Pioneer-10. The Pioneer-11 spacecraft, some 2.9 billion kilometers from Earth, continues to be tracked. The Pioneer-6 through -8 spacecraft are provided support during solar conjunctions and gravity wave experiments.

The DSN facilities are also used on a noninterference basis for ground based measurements in support of experiments in planetary radar mapping and in the field of radio astronomy. The ultrasensitive network antennas are being used in an attempt to learn more about pulsar high energy sources, quasars, and other interstellar and intergalactic phenomena.

Additional 34-meter antennas have been completed at both Goldstone and Canberra. These antennas have been electronically combined with the other antenna facilities at their respective complex to increase the receiver gain available at these two stations. Both of these stations are crucial to capturing imaging and science data from the Voyager-2 encounter with Uranus. The DSN complex at Canberra, because of its southern hemisphere location, has the best view of Voyager-2 at Uranus. At that location, an additional facility will be used at the time of encounter the additional facility is the Australian 64-meter Radio Observatory at Parkes, which will be electronically combined with an array of DSN antennas. The European Space Agency (ESA) will use this same Radio Observatory facility in support of their Giotto mission to Halley's Comet in March 1986. The arrival of Giotto at Halley's Comet at a time close to the Voyager-2 Uranus encounter requires close coordination between NASA, the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia, and ESA in order to assure mission success.

BASIS OF FY 1987 ESTIMATE

The DSN operations funding provides for the maintenance and operation of the consolidated network facilities, control center, and the support and engineering effort associated with both implementation activities and continuing operation of the network. The expected workload in 1987 on the DSN consists of support for the two Voyager spacecraft, the six ongoing Pioneer spacecraft (Pioneer 6, 7, 8, 10, 11 and Pioneer Venus), Active Magnetosphere Particle Tracer Explorer, International Sun Earth Explorer-1 and -2, Nimbus-7, Dynamics Explorer, Galileo, the Ulysses encounter with the planet Jupiter, and International Comet Explorer. Provision has also been made in the DSN to provide emergency backup support for Space Shuttle, TDRSS and Hubble Space Telescope.

	1985 Actual	1986 Budget Estimate	 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Aeronautics, balloons and sounding rocket support systems implementation	8,965	11,400	11,400	11,200

OBJECTIVES AND STATUS

The objectives of the Aeronautics, Balloons, and Sounding Rocket (AB&SR) Systems Implementation program are two fold. First, fixed and mobile instrumentation systems are provided to meet the tracking, data acquisition, and range safety requirements of the aeronautics research conducted at the Wallops Flight Facility (WFF) in Virginia, the Dryden Flight Research Facility (DFRF) and Moffett Field Flight Complex (MFFC) in California, and the scientific investigations conducted with balloons and sounding rockets at Wallops, the White Sands Missile Range, New Mexico; Poker Flats, Alaska; Palestine, Texas; and other selected sites around the world. Second, tracking and data acquisition support will be provided at Wallops to selected near-Earth orbiting satellites which cannot be supported by TDRSS. This function is being moved from Greenbelt, Maryland, to Wallops in April 1986 and will permit the closedown of that type of operations at Greenbelt.

BASIS OF FY 1987 ESTIMATE

The aeronautical research efforts and scientific experiments using sounding rockets and balloons are programs of a continuing nature which generally require about the same level of support from year to year. Support for these programs requires fixed and mobile instrumentation systems; namely, radar, telemetry, optical, communications, command, data handling and processing systems. To maintain these facilities, replacement parts must be acquired and test and calibration equipment routinely replaced. Due to the age of some of the radar, telemetry, and impact prediction equipment, a phased replacement and refurbishment program is underway to assure reliable real-time data collection and handling support to meet current and future requirements.

	1985 Actual	1986 Budget Estimate	 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Aeronautics, balloons and sounding rocket support operations...........	11,627	13,200	14,900	16,300

OBJECTIVES AND STATUS

Fixed and mobile instrumentation systems are maintained and operated to support sounding rocket, balloon, spacecraft, and aeronautics programs conducted by the Wallops Flight Facility (WFF), the Ames Research Center (ARC) at its Dryden Flight Research Facility (DFRF), and Moffett Field Flight Complex (MFFC). These instrumentation systems include radar, telemetry, data processing, data handling, and communications systems, as well as special purpose optical equipment.

The Sounding Rocket program continues to be an active program with approximately 110 launches in FY 1985, most of which were conducted at WFF. In addition, there were approximately 190 balloon flights during the same period. At WFF, the aeronautics programs are primarily related to investigation of aircraft handling characteristics, advanced control and display concepts, spin and stall tests, terminal area guidance and traffic control systems, and storm dynamics studies. During 1985, approximately 275 research missions were conducted. In addition to support of sounding rocket, balloon, and aeronautics programs, instrumentation at WFF will continue to be utilized to support the shuttle orbital flights with C-band radar support.

ARC operates aeronautical test ranges at DFRF and MFFC which provide radar, telemetry, optical, and communications support for the performance of aircraft research and development programs. A variety of programs are conducted at these facilities involving high performance aircraft such as the F-111, F-18A, F-16, F-104, F-8, X-29A, and unique research vehicles such as the tilt-rotor research aircraft, composite rotorcraft, and the X-wing aircraft. Nearly 500 aeronautical research missions were supported at DFRF and approximately 275 at MFFC during FY 1985. DFRF continues to serve as an alternative landing site for the Space Shuttle.

CHANGES FROM THE FY 1986 BUDGET ESTIMATE

The increase of $1.7 million reflects the decision to transfer operations from the Greenbelt, Maryland tracking station to the Wallops Flight Facility in April 1986.

BASIS OF FY 1987 ESTIMATE

The FY 1987 funding requirements provide engineering and technical services for maintenance and operation of fixed and mobile radar, telemetry, optical, communications, and data handling and processing equipment and facilities to support the ongoing sounding rocket, balloon, orbiting satellites, and aeronautical research activities. It includes the first full year of funding for the transfer of operations from Greenbelt, Maryland to the Wallops Flight Facility.

BASIS OF FY 1987 FUNDING REQUIREMENT

COMMUNICATIONS AND DATA SYSTEMS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Communications systems implementation	6,500	6,500	5,000	6,200
Communications operations............	73,000	75,700	83,200	82,000
Mission facilities..................	12,675	13,300	13,300	6,900
Mission operations..................	21,200	27,100	24,000	29,300
Data processing systems implementation	25,016	24,100	25,000	25,100
Data processing operations...........	45,809	41,500	41,500	53,100
Total............................	184,200	188,200	192,000	202,600

OBJECTIVES AND STATUS

Funds requested for the Communications and Data Systems program provide for the implementation and operation of facilities and systems which are required for data transmission, mission control and data processing support.

Communication circuits and services provide for the transmission of data among the remote tracking and data acquisition facilities, launch areas, and the mission control centers. Real-time information is crucial to determining the condition of the spacecraft and payloads for the generation of commands for spacecraft and payload control. Data received from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. Missions supported include Shuttle, Spacelab, NASA scientific and application projects and international cooperative efforts.

Major activities underway include the implementation of: 1) the Program Support Communications Network (PSCN) which provides for the day-to-day communications among NASA field centers and Headquarters; 2) a mission control and data capture system for Hubble Space Telescope and 3) Mission Control and data processing capabilities for support of upcoming missions such as Spacelabs, Gamma Ray Observatory (GRO) and Upper Atmosphere Research Satellite (UARS). In addition, preliminary studies have been initiated to evaluate Space Station support requirements.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Communications systems implementation......................	6,500	6,500	5,000	6,200

OBJECTIVES AND STATUS

The objective of the Communications Systems Implementation Program is to provide the necessary capability in NASA's Global Communications Network to meet new program support requirements, to increase the efficiency of the network, and to keep NASCOM at a high level of reliability for the transmission of data. NASCOM interconnects the tracking and data acquisition facilities which support all flight projects; it also links such facilities as launch areas, test sites, and mission control centers.

The major effort underway in NASCOM is the phased replacement of the digital voice and data message switching system at the Goddard Space Flight Center (GSFC).

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $1.5 million results from rephasing of the funding for the operational network digital voice and data message switching system to coincide with the availability of other communications equipment at the Goddard Space Flight Center (GSFC).

BASIS OF 1987 ESTIMATE

The FY 1987 funding requirements will provide the sustaining equipment and modifications to support the NASCOM network and continue implementation of the replacement digital voice and data message switching system at GSFC. Effort will continue on the use of advanced digital techniques for Time-Division-Multiple-Access (TDMA) via satellite. With the completion of the 15 MBS system at 14 locations in FY 1986, implementation and augmentation for a 60 MBS capability at selected NASA Centers will be initiated in FY 1987 to meet growing requirements.

On-line operation of the Control and Status System (CSS) is scheduled for mid-1987. This system will provide real-time performance information and automate the manual switching function for the baseline Tracking and Data Relay Satellite (TDRS) communication system. The baseline TDRS communications system ties together the Goddard Space Flight Center (GSFC), Johnson Space Center (JSC), Marshall Space Flight Center (MSFC), and the TDRSS ground terminal in New Mexico.

		1986		
	1985 Actual	Budget Estimate	Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Communications operations.............	73,000	75,700	83,200	82,000

OBJECTIVES AND STATUS

NASA's Global Communications Network (NASCOM) interconnects, by means of leased voice, data, and wideband circuits, the tracking and data acquisition facilities which support all flight projects. NASCOM also links such facilities as launch areas, test sites, and mission control centers. Goddard Space Flight Center (GSFC) operates the NASCOM and serves as its major switching control point. In the interest of economy, reliability, and full utilization of trunk circuitry, subswitching centers have been established at key domestic and overseas locations. The NASA flight projects require the transfer of data between the mission control centers and the sites because of the need for real time control of spacecraft and on-board experiments. In addition, there are requirements to provide experiment data expeditously to users for analysis. NASA's Program Support Communications Network (PSCN) interconnects by means of leased voice, data, and wideband circuits the NASA Centers, Headquarters, and major contractor locations for the transfer of programmatic and administrative information. Marshall Space Flight Center (MSFC) operates the PSCN and serves as its major switching control point.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The increase of $7.5 million is attributable to the need to provide communications with the STDN tracking sites for Shuttle support longer than planned due to the delay in the Tracking and Data Relay Satellite launches.

BASIS OF FY 1987 ESTIMATE

The FY 1987 funding requirements for Communications Operations will provide the circuits and service required to operate and maintain the NASA Global Communications Network. International communications satellites and cable systems will continue to provide digital wideband services to all the overseas tracking stations. Domestic satellite systems and terrestrial networks will continue to service the continental United States stations. The initiation and transfer of selected domestic satellite services to the TDRSS C-Band transponders will be undertaken with other government users reimbursing NASA for their portion of the service. It is anticipated that NASCOM's TDMA based network and the PSCN backbone network will also utilize the TDRS satellite C-Band capability.

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Construction of Facilities

In addition, funds are included for the Program Support Communications Network (PSCN) which provide for the circuits and facilities for programmatic and day-to-day operations such as facsimile, teleconferencing, data transmission, and computer-to-computer data sharing for NASA Centers and Headquarters. In FY 1987 funds are required to operate and maintain the PSC network hardware and wideband satellite and terrestrial circuits at all NASA locations and selected contractor sites. The network will support all NASA programs and projects such as the Space Transportation System, Hubble Space Telescope, and Space Station management information system. In addition, the network will support administrative and institutional information systems.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Mission facilities....................	12,675	13,300	13,300	6,900

OBJECTIVES AND STATUS

The Mission Facilities Implementation Program provides the systems capability for the command and control of NASA's unmanned scientific and applications satellite programs. Command and control of the spacecraft and on-board experiments are carried out via Payload Operations Control Centers (POCC's) and related Mission Support Systems (MSS).

The POCC's are responsible for the receipt, processing, and display of spacecraft engineering data and the transmission of commands. Four POCC's currently monitor and control numerous spacecraft. In addition, a new dedicated control center will be operational in FY 1986 to control the Hubble Space Telescope scheduled for launch in late 1986. Related mission support systems include a Johnson Space Center/Goddard Space Flight Center Shuttle POCC Interface Facility (SPIF) and a Mission Planning System to plan and schedule spacecraft support.

BASIS OF 1987 ESTIMATE

The FY 1987 funding requirements will provide for Hubble Space Telescope post launch software enhancements based upon on-orbit performance of the spacecraft and science instruments. Certain control center parameters related to focusing of the telescope and calibration of the optics can only be determined and implemented after the Hubble Space Telescope is in orbit.

In addition, FY 1987 funds will provide for modifications to the existing Multisatellite Operations Control Center (MSOCC) for control of the Gamma Ray Observatory (GRO), Cosmic

Background Explorer (COBE), Upper Atmosphere Research Satellite (UARS), and various Shuttle attached payloads. In FY 1987 control center developments to permit spacecraft payload operations from user facilities will also be initiated. This new concept which is planned for use with Space Station will provide operational efficiencies for experimenters.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Mission operations....................	21,200	27,100	24,000	29,300

OBJECTIVES AND STATUS

The Mission Operations Program in FY 1987 will provide for the operation of five Payload Operations Control Centers (POCC's) and the related software and support services necessary for the monitoring and control of ten in-orbit spacecraft.

These POCC's, which are the control facilities for spacecraft/payload operations, have the capability for receiving, processing, and displaying spacecraft engineering and telemetry data for sending commands to the spacecraft. Commands transmitted to the spacecraft include both emergency commands resulting from decisions made by the spacecraft analysts as well as preplanned command sequences generated in advance to carry out the mission objectives. Each POCC is operated 24 hours per day, 7 days per week. For Shuttle launches with attached payloads, for which GSFC has responsibility, there is a specialized GSFC Shuttle Payload Interface Facility (SPIF) which processes and provides for the display of Shuttle-unique data that is necessary for payload control.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The decrease of $3.1 million is due to reduced and rephased software requirements in the POCC and Command Management facilities.

BASIS OF FY 1987 ESTIMATE

The FY 1987 budget request includes funds to operate POCC's and supporting facilities for control of on-orbit missions and control center software development for supporting upcoming missions. In FY 1987 the new Hubble Space Telescope POCC will be operational and a major activity that will be conducted in this facility after launch is the operational checkout and calibration of the spacecraft and scientific instruments. Also in FY 1987, software development activities will continue to increase for the COBE and UARS missions. Softwars to enable POCC control of the GRO will continue along with SPIF software development.

Also included in the FY 1987 budget request are funds for software and related support services which include maintenance of a software library, computer-generation of command sequences, equipment maintenance, engineering, logistics and documentation services.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Data processing systems implementation	25,016	24,100	25,000	25,100

OBJECTIVES AND STATUS

The Data Processing Systems Implementation Program provides for the procurement of equipment and related services for the large data processing and computation systems at the Goddard Space Flight Center (GSFC) which support both the operational and payload requirements of space missions. To meet operational requirements, these systems determine spacecraft attitude and orbit and generate on-board commands to the spacecraft subsystems. In support of spacecraft payloads, the systems process the data from science and applications experiments for subsequent transfer to the experimenters for analysis.

Major computation capabilities include the Flight Dynamics Facility which performs the real time attitude, orbit computation and flight maneuver control functions and the Command Management System which provides memory management for on-board computers. There are three major systems for processing data: 1) the Telemetry On-Line Processing System (TELOPS) which routinely supports a number of Earth-orbiting spacecraft; 2) The Image Processing Facility which generates products for Landsat and Nimbus 7 and, 3) The Spacelab Data Processing Facility (SLDPF) which supported the Spacelab 1, 2, 3 and D1 missions and the Shuttle Imaging Radar-B experiment.

Significant activities in this program continue at the Goddard Space Flight Center to keep the large systems viable and responsive to project support requirements. Implementation continues on a new system to process data from numerous and varied experiments which comprise the payloads of early Spacelab missions and new payloads associated with later missions. The early Spacelab missions may be described generally as multi-discipline missions consisting of a mixture of experiments in areas such as life science, microgravity, space plasma, etc., whereas the later Spacelab missions place emphasis on a single discipline and are called Dedicated Discipline Laboratory (DDL) missions. Examples of DDL missions are the Attached Shuttle Astronomy Payload (ASTRO 1, 2, & 3), the Earth Observation Missions (EOM) 1 and 2, and the Shuttle High Energy Astrophysics Laboratory (SHEAL).

Also included is the development of a test bed facility to be used for prototyping, testing and evaluating maturing technologies resulting from the Advanced Systems Program. Promising technologies for application to future support will be investigated in the areas of remote payload operation and control, expert systems, high speed date processing, high level languages, and advanced data base management systems.

CHANGES FROM FY 1986 BUDGET ESTIMATE

The increase of $.9 million is due to revised data processing requirements including studies and analyses of support for upcoming missions.

BASIS OF FY 1987 ESTIMATE

The FY 1987 budget request will provide funding for continuing the phased replacement of the existing computation systems at the Goddard Space Flight Center which provide real-time support to NASA spacecraft. Included in the support are such critical activities as real-time attitude and orbit determination, memory management for on-board computers, and flight maneuver control.

The funding request provides for continuing the phased replacement program for the Command Management System (CMS) and the Orbit Computation System (OCS) at GSFC. The initial phase for replacing the CMS system has been completed and this funding provides for initiating the final phase of the replacement plan. Also, funding is included for replacing custom displays and large application software programs for the OCS. In addition, the request provides for the improvement/upgrade of the Flight Dynamics Facility (FDF) and for systems studies in autonomous navigation as part of the test bed/prototyping activity.

Funds are required in FY 1987 to continue the implementation of an institutional packet telemetry processing system with the Gamma Ray Observatory (GRO) as its first user. This facility will capture, error check, and ship real-time, quick-look and production scientific data to various users. The system is necessary to handle the "packet" telemetry and to assure support over the long mission lifetime of GRO and other spacecraft. The "packet" telemetry concept allows the scientific data of an experiment to be handled with minimum involvement by the ground system, thus reducing ground data processing time as well as ensuring faster delivery of data to the experimenters.

Funds are also required in FY 1987 to continue the augmentation of the SLDPF to support missions such as International Microgravity Laboratory (IML), ASTRO -2 and -3, EOM-3, SHEAL, Sunlab 1 and the Shuttle Radar Lab (SRL-2). The Dedicated Discipline Laboratory (DDL) missions will be flown more frequently than the earlier Spacelab missions, and will require more concurrent support and quicker release of experiment data to the scientific community.

The FY 1987 budget request includes funds to continue the upgrade of the existing TELOPS in order to develop a generic time division multiplexed (TDM) system of which the Upper Atmosphere Research Satellite (UARS) will be the first user. The handling of UARS data will serve as a baseline for providing such support to other users allowing for tradeoffs between development costs and support risks for future missions.

There is a continuing requirement to procure and maintain an adequate supply of unique spare parts to replace failure-prone and high-maintenance electronic modules, to provide test equipment, and to undertake minor modifications and hardware fabrication associated with new equipment installation and reconfiguration. Funds are also included in the request for continuing the evaluation of Space Station support requirements and the capabilities needed to provide such support.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Data processing operations............	45,809	41,500	41,500	53,100

OBJECTIVES AND STATUS

Information received in the form of tracking and telemetry data from the various spacecraft must be processed into a usable form before transfer to control centers and experimenters. This transformation and computation process is performed as part of the data processing function and applies to a wide variety of programs, ranging from the small explorer satellites to complex imaging type satellites such as Landsat and Nimbus.

In addition to the actual processing of the data, upcoming projects require extensive prelaunch orbit analysis including spacecraft position and attitude predictions. Analyses are also required to develop operational sequences and procedures to be used during the actual operation of these complex spacecraft.

Telemetry data is the primary product of spacecraft and it is through reduction and analysis of this data by the experimenters that the planned objectives are achieved. Data is processed to separate the information obtained from various scientific experiments aboard the spacecraft, consolidate information for each experimenter, determine spacecraft attitude, and correlate these measurements with spacecraft position data. Three facilities, the Image Processing Facility (IPF), the Telemetry On-Line Processing System (TELOPS), and the Spacelab Data Processing Facility (SLDPF), have been established at the Goddard Space Flight Center to pre-process different types of raw experimental data.

The IPF, initially established to handle image data from the Landsat-1, has supported Landsat-2 and Landsat-3 and presently is processing residual data from these spacecraft as well as current data from the Nimbus mission. These spacecraft are being supported with an all-digital system using high density recorders and computer compatible tapes. This equipment is being used currently to process archived Landsat data now required for climatic and meteorological studies. This data was processed initially into film and picture products; however, the scientific community requires the data to be reprocessed with the output in the form of digital tapes. The digital data can be manipulated in the scientist's computer with specific algorithms to enhance the interpretation of the data and related phenomena.

The Telemetry On-Line Processing System (TELOPS) handles the non-image data. TELOPS receives satellite data in a digital form from the tracking stations via the NASA global communications network lines and is able to electronically store large volumes of telemetry data, thus eliminating most of the tape and tape handling operations. Facility management, maintenance and operations, and software development support for the image and non-image data processing facilities are also provided. The operation of the Spacelab Data Processing Facility is included along with software development and maintenance required for attitude determination, flight maneuvers, and mission simulations.

BASIS OF FY 1987 ESTIMATE

FY 1987 budget request includes funds to operate the Image Processing Facility (IPF), the Hubble Space Telescope Data Capture Facility (HSTDCF), and the Telemetry On-Line Processing System (TELOPS). Also, funds are necessary for operation of the SLDPF which includes maintenance of unique hardware and software for Spacelab and Dedicated Discipline Laboratory (DDL) missions.

Application software development, prototyping, and system testing activities are continuing or will be initiated in support of upcoming space science and applications missions such as Cosmic Background Explorer, Gamma Ray Observatory, Shuttle Attached Payloads, and the Upper Atmosphere Research Satellite. For on-orbit spacecraft, software development and maintenance is required on a continuing basis in order to perform attitude control maneuvers and for data processing activities.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

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Project Justification by Location:

Lyndon B. Johnson Space Center .... CF 1
Space Station Facilities at Various Locations .... CF 2
Space Flight Facilities at Various Locations .... CF 3
Goddard Space Flight Center, Greenbelt, Maryland .... CF 4
Jet Propulsion Laboratory, Pasadena, California .... CF 5
Ames Research Center, Moffett Field, California .... CF 6
Dryden Flight Research Facility, Edwards, California .... CF 7
Langley Research Center, Hampton, Virginia .... CF 8
Various Locations .... CF 9
Repair .... CF 10
Rehabilitation and Modification .... CF 11
Minor Construction .... CF 12
Facility Planning and Design .... CF 13

THIS DOCUMENT DOES NOT REFLECT: (1) THE FY 1986 REDUCTIONS THAT ARE LIKELY TO RESULT UNDER THE BALANCED BUDGET AND EMERGENCY DEFICIT CONTROL ACT OF 1985; OR (2) THE EFFECTS RESULTING FROM THE LOSS OF THE CHALLENGER AND CREW ON JANUARY 28, 1986. PROPOSED CHANGES IN PROGRAM PLANS AND BUDGET ESTIMATES WILL BE TRANSMITTED LATER.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

GENERAL STATEMENT

The Construction of Facilities (CoF) appropriation provides contractual services for the repair, rehabilitation and modification of existing facilities; the construction of new facilities; the acquisition of related facility equipment; the design of facilities projects; and advance planning related to future facilities needs.

The funds requested for 1987 provide for: the continuation of prior year's endeavors in meeting the facilities requirements for Space Flight; modification of aeronautical research and development facilities; repair, rehabilitation and modification of other facilities to maintain, upgrade and improve the usefulness of the NASA physical plant; minor construction of new facilities; and facility planning and design activities.

The projects and amounts in the budget estimate reflect Space Flight requirements that are time sensitive to meet specific milestones. Other program requirements for 1987 include the construction of a central computing facility at the Johnson Space Center; construction of a spacecraft systems development and integration facility at the Goddard Space Flight Center; construction of an engineering support building, and modification of the uninterruptible power system in the space flight operations facility at the Jet Propulsion Laboratory; construction of a human performance research laboratory at the Ames Research Center; construction of an integrated test facility at Dryden Flight Research Facility; construction of an addition for the nondestructive evaluation research laboratory, and modifications to the 8-foot high temperature tunnel at the Langley Research Center; construction of a power systems facility at the Lewis Research Center; and the construction of the second tracking and data relay satellite system ground terminal facility, New Mexico.

The FY 1987 program continues to meet the objectives of preserving and enhancing the capabilities and usefulness of existing facilities and ensuring safe economical and efficient use of the NASA physical plant. This request continues the necessary rehabilitation and modification program begun in prior years and continues a repair program. The purpose of the repair program is to restore facilities to a condition substantially equivalent to their originally designed capability. The minor construction program continues to provide a means to accomplish smaller facility projects which accommodate changes in technical and institutional requirements.

Funds requested for facility planning and design cover advance planning and design requirements for potential future projects, master planning, facilities studies, engineering reports and studies and the preparation of facility project design drawings and bid specifications.

The budget authority requested for FY 1987 is $181,300,000, with estimated outlays of $148,700,000.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPROSED APPROPRIATION LANGUAGE

CONSTRUCTION OF FACILITIES

For construction, repair, rehabilitation and modification of facilities, minor construction of new facilities and additions to existing facilities, and for facility planning and design not otherwise provided, for the National Aeronautics and Space Administration, and for the acquisition or condemnation of real property, as authorized by law, [$139,300,000] *$181,300,000*, to remain available until September 30, [1988] *1989*: *Provided*, That, notwithstanding the limitation on the availability of funds appropriated under this heading by this appropriation Act, when any activity has been initiated by the incurrence of obligations therefor, the amount available for such activity shall remain available until expended, except that this provision shall not apply to the amounts appropriated pursuant to the authorization for repair, rehabilitation and modification of facilities, minor construction of new facilities and additions to existing facilities, and facility planning and design: *Provided further*, That no amount appropriated pursuant to this or any other Act may be used for the lease or construction of a new contractor-funded facility for exclusive use in support of a contract or contracts with the National Aeronautics and Space Administration under which the Administration would be required to substantially amortize through payment or reimbursement such contractor investment, unless an appropriation Act specifies the lease or contract pursuant to which such facilities are to be constructed or leased or such facility is otherwise identified in such Act: *Provided further*, That the Administrator may authorize such facility lease or construction, if he determines, [in consultation] with *notice to* the Committees on Appropriations, that deferral of such action until the enactment of the next appropriation Act would be inconsistent with the interest of the Nation in aeronautical and space activities. *(Department of Housing and Urban Development-Independent Agencies Appropriation Act, 1986; additional authorizing legislation to be proposed.)*

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1987 ESTIMATES

SUMMARY OF THE BUDGET PLAN BY LOCATION

Location	FY 1985	FY 1986 (In Dollars)	FY 1987
Lyndon B. Johnson Space Center	---	---	9,000,000
George C. Marshall Space Flight Center	1,600,000	---	---
Space Station Facilities	---	---	12,900,000
Space Flight Facilities	38,800,000	29,900,000	3,400,000
Space Shuttle Payload Facilities	6,700,000	1,200,000	---
Goddard Space Flight Center	2,200,000	3,800,000	8,000,000
Jet Propulsion Laboratory	12,200,000	8,900,000	12,400,000
Ames Research Center	11,500,000	8,200,000	9,400,000
Dryden Flight Research Facility	---	---	17,500,000
Langley Research Center	13,800,000	4,900,000	11,700,000
Various Locations	13,800,000	17,400,000	22,000,000
Repair	18,000,000	22,000,000	24,000,000
Rehabilitation and Modification	22,000,000	26,000,000	30,000,000
Minor Construction	5,000,000	6,000,000	7,000,000
Facility Planning and Design	12,000,000	11,000,000	14,000,000
Total Plan	157,600,000	139,300,000	181,300,000

SUMMARY OF BUDGET PLAN BY COGNIZANT OFFICE

	FY 1985	FY 1986 (In Dollars)	FY 1987
Office of Space Station	---	---	12,900,000
Office of Space Flight	45,000,000	31,100,000	12,400,000
Office of Space Science and Applications	12,200,000	12,700,000	20,400,000
Office of Aeronautics and Space Technology	27,400,000	13,100,000	38,600,000
Office of Space Tracking and Data Systems	16,000,000	17,400,000	22,000,000
Office of Management	57,000,000	65,000,000	75,000,000
Total Plan	157,600,000	139,300,000	181,300,000

SUMMARY OF BUDGET PLAN BY SUBFUNCTION

Code No.		FY 1985	FY 1986	FY 1987
253	Space Flight	38,800,000	29,900,000	10,500,000
254	Space Science, Applications, and Technology	8,300,000	5,000,000	23,200,000
255	Support Space Activities	85,200,000	91,300,000	118,400,000
(250)	Subtotal, General Science, Space and Technology	132,300,000	126,200,000	152,100,000
402	Air Transportation	25,300,000	13,100,000	29,200,000
	Total	157,600,000	139,300,000	181,300,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1987 ESTIMATES

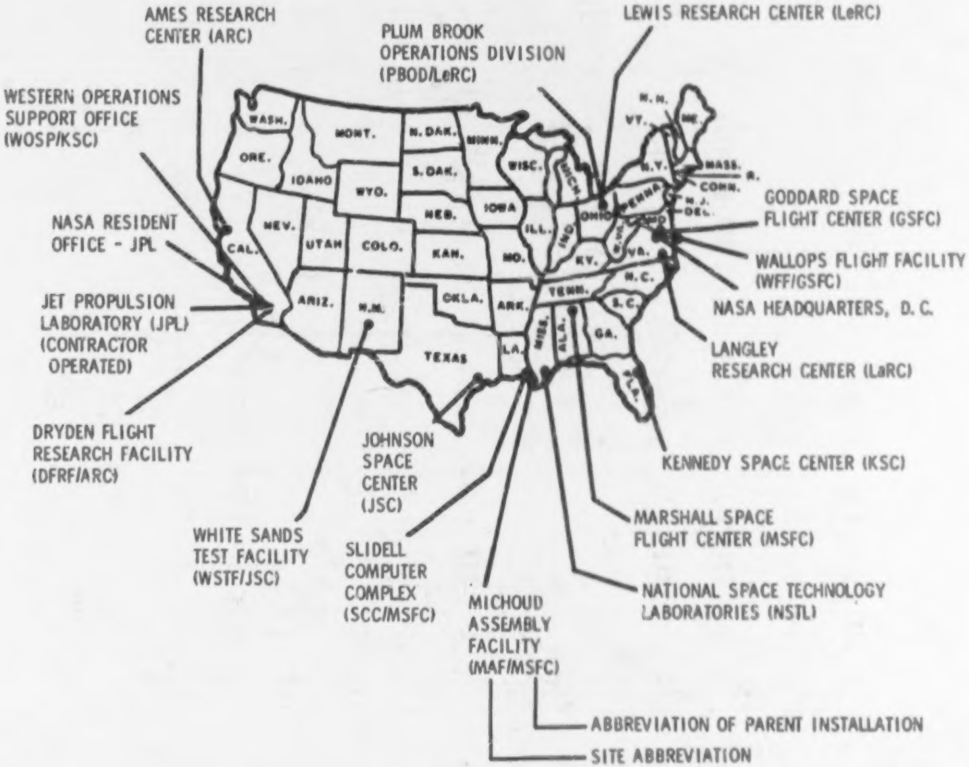
SUMMARY OF THE BUDGET PLAN BY LOCATION

Cognizant Office	Budget Activity	Subfunction Code	Location and Project	FY 1985	FY 1986	FY 1987	Page No.
				(Thousands of Dollars)			
			LYNDON B. JOHNSON SPACE CENTER..................................	---	---	9,000	
SF	7	255	Construction of Central Computing Facility....................	---	---	9,000	CF 1-1
			GEORGE C. MARSHALL SPACE FLIGHT CENTER..........................	1,600	---	---	
SF	4	254	Repairs to Test Stand 500.......................................	1,600	---	---	
			SPACE STATION FACILITIES AT VARIOUS LOCATIONS, AS FOLLOWS:.....	---	---	12,900	
SS	1	253	Construction of Addition to the Systems Integration and Mockup Laboratory (JSC).................................	---	---	5,000	CF 2-1
SS	4	254	Construction of Power Systems Facility (LeRC)................	---	---	5,800	CF 2-8
SS	1	253	Modifications to Test Stand 300 for Space Station Hydrogen/ Oxygen Propulsion Systems Development (MSFC)................	---	---	2,100	CF 2-15
			SPACE FLIGHT FACILITIES AT VARIOUS LOCATIONS, AS FOLLOWS:......	38,800	29,900	3,400	
SF	1	253	Construction of Addition to Orbiter Processing Facility Annex (KSC)..	---	---	3,400	CF 3-1
SF	1	253	Construction of Orbiter Modification and Refurbishment Facility (KSC)...	---	14,000	---	
SF	1	253	Construction of Thermal Protection System Facility (KSC).......	---	3,600	---	
SF	1	253	Modifications for Advanced Technology Engine Test Stand S-1C (MSFC)..	---	6,500	---	
SF	1	253	Modifications for Enhanced Life Support Systems Testing (JSC)..	---	1,100	---	
SF	1	253	Modifications to Pad A Payload Change-Out Room (KSC)..........	---	2,200	---	
SF	1	253	Modifications to Space Shuttle Main Engine Support Systems (NSTL)...	---	2,500	---	

Cognizant Office	Budget Activity	Subfunction Code	Location and Project	FY 1985	FY 1986	FY 1987	Page No.
				(Thousands of Dollars)			
SF	1	253	Construct Easter Island Runway Extension (KSC)................	7,600	---	---	
SF	1	253	Construction of Launch Complex 39 Logistics Facility (KSC).....	9,700	---	---	
SF	1	253	Construction of Solid Rocket Booster Assembly and Refurbishment Facility (KSC)................................	15,000	---	---	
SF	1	253	Modification of Site Electrical Substation (JSC)..............	3,200	---	---	
SF	1	253	Modifications for Single Engine Testing (NSTL).................	3,300	---	---	
			SPACE SHUTTLE PAYLOAD FACILITIES AT VARIOUS LOCATIONS, AS FOLLOWS:...	6,700	1,200	---	
SF	2	254	Construction of Payload Control Rooms (KSC)....................	---	1,200	---	
SF	2	254	Construction of Additions to Cargo Hazardous Servicing Facility (KSC)...	4,600	---	---	
AST	2	254	Construction of Biomedical Research Facility (ARC)............	2,100	---	---	
			GODDARD SPACE FLIGHT CENTER....................................	2,200	3,800	8,000	
SSA	2	254	Construction of Spacecraft Systems Development and Integration Facility..	---	---	8,000	CF 4-1
SSA	2	254	Construction of Addition to Research Project Laboratory........	---	3,800	---	
ST&DS	7	255	Construction of Addition to the Network Control Center.........	2,200	---	---	
			JET PROPULSION LABORATORY......................................	12,200	8,900	12,400	
SSA	7	255	Construction of Engineering Support Building...................	---	---	9,800	CF 5-1
SSA	7	255	Modification of Uninterruptible Power System in Space Flight Operations Facility..	---	---	2,600	CF 5-8
SSA	7	255	Construction of Microdevices Laboratory........................	---	8,900	---	
SSA	7	255	Construction of Earth and Space Science Laboratory.............	12,200	---	---	
			AMES RESEARCH CENTER...	11,500	8,200	9,400	
AST	4	254	Construction of Human Performance Research Laboratory..........	---	---	9,400	CF 6-1
AST	5	402	Construction of Numerical Aerodynamic Simulation Facility......	11,500	8,200	---	
			DRYDEN FLIGHT RESEARCH FACILITY................................	---	---	17,500	
AST	5	402	Construction of Integrated Test Facility.......................	---	---	17,500	CF 7-1

Cognizant Office	Budget Activity	Subfunction Code	Location and Project	FY 1985	FY 1986	FY 1987	Page No.
				(Thousands of Dollars)			
			LANGLEY RESEARCH CENTER	13,800	4,900	11,700	
AST	5	402	Modifications to 8-Foot High Temperature Tunnel	13,800	---	9,700	CF 8-1
AST	5	402	Construction of Addition for Non-Destructive Evaluation Research Laboratory	---	---	2,000	CF 8-8
AST	5	402	Modifications to 16-Foot Transonic Tunnel for Improved Productivity and Research Capability	---	4,900	---	
			VARIOUS LOCATIONS	13,800	17,400	22,000	
ST&DS	7	255	Construction of the Second Tracking and Data Relay Satellite System Ground Terminal Facility in New Mexico	---	---	22,000	CF 9-1
ST&DS	7	255	Modification of 64-Meter Antenna DSS-14, Goldstone California (JPL)	---	8,500	---	
ST&DS	7	255	Modification of 64-Meter Antenna DSS-43, Canberra, Australia (JPL)	---	8,900	---	
ST&DS	7	255	Construction of 34-Meter Antenna, Madrid, Spain (JPL)	6,000	---	---	
ST&DS	7	255	Modifications of 64-Meter Antenna, DSS-63, Madrid, Spain (JPL).	7,800	---	---	
MGMT	7	255	Repair of Facilities at Various Locations, Not in Excess of $750,000 Per Project	18,000	22,000	24,000	CF 10-1
MGMT	7	255	Rehabilitation and Modification of Facilities at Various Locations, Not in Excess of $750,000 Per Project	22,000	26,000	30,000	CF 11-1
MGMT	7	255	Minor Construction of New Facilities and Additions to Existing Facilities at Various Locations, Not in Excess of $500,000 Per Project	5,000	6,000	7,000	CF 12-1
MGMT	7	255	Facility Planning and Design	12,000	11,000	14,000	CF 13-1
			TOTAL	157,600	139,300	181,300	

LOCATION OF MAJOR AND COMPONENT INSTALLATIONS


AMES RESEARCH CENTER (ARC)
PLUM BROOK OPERATIONS DIVISION (PBOD/LeRC)
LEWIS RESEARCH CENTER (LeRC)
WESTERN OPERATIONS SUPPORT OFFICE (WOSP/KSC)
GODDARD SPACE FLIGHT CENTER (GSFC)
NASA RESIDENT OFFICE - JPL
WALLOPS FLIGHT FACILITY (WFF/GSFC)
NASA HEADQUARTERS, D. C.
JET PROPULSION LABORATORY (JPL) (CONTRACTOR OPERATED)
LANGLEY RESEARCH CENTER (LaRC)
DRYDEN FLIGHT RESEARCH FACILITY (DFRF/ARC)
JOHNSON SPACE CENTER (JSC)
KENNEDY SPACE CENTER (KSC)
MARSHALL SPACE FLIGHT CENTER (MSFC)
WHITE SANDS TEST FACILITY (WSTF/JSC)
SLIDELL COMPUTER COMPLEX (SCC/MSFC)
MICHOUD ASSEMBLY FACILITY (MAF/MSFC)
NATIONAL SPACE TECHNOLOGY LABORATORIES (NSTL)
ABBREVIATION OF PARENT INSTALLATION
SITE ABBREVIATION
WASH.
ORE.
CAL.
IDAHO
NEV.
MONT.
WYO.
UTAH
ARIZ.
COLO.
N.M.
N. DAK.
S. DAK.
NEB.
KAN.
OKLA.
TEXAS
MINN.
IOWA
MO.
ARK.
LA.
WISC.
ILL.
MICH.
IND.
OHIO
KY.
TENN.
MISS.
ALA.
GA.
FLA.
S.C.
N.C.
VA.
W.VA.
PENNA.
MD.
N.Y.
VT.
N.H.
ME.
MASS.
CONN.
R.
N.J.
DEL.

SUM 8

RECORDED VALUE OF CAPITAL TYPE PROPERTY
IN-HOUSE AND CONTRACTOR-HELD
AS OF SEPTEMBER 30, 19[illegible]
(DOLLARS IN THOUSANDS)

REPORTING INSTALLATION	REAL PROPERTY LAND	BUILDINGS	OTHER STRUCTURES/LEASEHOLD AND FACILITIES	IMPROVEMENTS	TOTAL	EQUIPMENT	FIXED ASSETS IN PROGRESS	GRAND TOTAL
AMES RESEARCH CENTER	2989	[illegible]	[illegible]	0	[illegible]	[illegible]	138730	[illegible]
ARC MOFFETT FIELD, CA	[illegible]	319761	11990	0	[illegible]	247138	128995	[illegible]
DRYDEN FLIGHT FACILITY EDWARDS, CA	0	18030	13510	0	31366	88945	9657	125130
VARIOUS LOCATIONS (a)	1	696	346	0	1043	24861	-50	25884
GODDARD SPACE FLIGHT CENTER	2840	158875	111884	0	[illegible]	315074	37999	801561
GSFC - GREENBELT, MD	1361	108990	10617	0	[illegible]	[illegible]	28994	402181
TRACKING STATIONS NETWORK	5	14174	50681	0	[illegible]	143385	2513	212570
WFF - WALLOPS ISLAND, VA	1474	35666	61730	0	98870	60484	4085	163738
VARIOUS LOCATIONS (a)	0	45	13	0	58	41096	0	41154
JET PROPULSION LABORATORY	1100	106540	[illegible]	1090	[illegible]	[illegible]	25842	[illegible]
JPL - PASADENA, CA	1100	[illegible]	15040	1091	[illegible]	[illegible]	25840	[illegible]
[illegible] SPACE NETWORK	0	18676	69007	2	[illegible]	72641	0	154626
JOHNSON SPACE CENTER	[illegible]	213736	[illegible]	0	[illegible]	[illegible]	8486	[illegible]
JSC - HOUSTON, TX	7319	176488	48129	0	[illegible]	[illegible]	6745	[illegible]
WHITE SANDS TEST FACILITY LAS CRUCES, NM		9702	21508		31210	18130	0	[illegible]
VARIOUS LOCATIONS (a)	3570	27610	3071	0	[illegible]	[illegible]	1740	[illegible]
KENNEDY SPACE CENTER	71045	[illegible]	472546	0	976604	600003	95994	1677300
KSC - CAPE CANAVERAL, FL	71045	[illegible]	472546		976604	166605	95994	[illegible]
WESTERN TEST RANGE, LOMPOC, CA					0	104853	0	104853
VARIOUS LOCATIONS (a)	0	0	0	0	0	304117	0	304117
LANGLEY RESEARCH CENTER	162	136907	300139	0	[illegible]	[illegible]	10946	765050
LARC - HAMPTON, VA	162	136907	300180		[illegible]	[illegible]	10946	750140
VARIOUS LOCATIONS (a)	0	0	51	0	51	13009	0	13110
LEWIS RESEARCH CENTER	8421	211369	91909	186	313956	[illegible]	85479	580814
LERC - CLEVELAND, OH	314	134862	[illegible]	186	210601	150714	85479	402374
PLUMBROOK, SANDUSKY, OH	8001	76487	19968		97774	6879	0	154047
VARIOUS LOCATIONS (a)	0	0	0	0	0	17898	0	17898
MARSHALL SPACE FLIGHT CENTER	7164	[illegible]	140770	0	[illegible]	[illegible]	0	[illegible]
MSFC - HUNTSVILLE, AL	0	129537	60816	0	190150	271900	0	467360
MICHOUD ASSEMBLY FACILITY, LA	7095	114540	[illegible]	0	107570	38016	0	[illegible]
SLIDELL COMPUTER COMPLEX, LA	69	3430	3710	0	7014	6871	0	14786
VARIOUS LOCATIONS (a)	0	[illegible]	10707	0	15066	[illegible]	0	110009
NATIONAL SPACE TECH. LABS	10061	[illegible]	198871	0	[illegible]	[illegible]	0	[illegible]
NSTL - NSTL STATION, MS	10061	[illegible]	198871	0	[illegible]	[illegible]	0	[illegible]
VARIOUS LOCATIONS (a)	0	0	0	0	0	61	0	61
NASA HEADQUARTERS	0	0	0	0	0	31140	0	31140
NASA - HQS., WASH., D C	0	0	0	0	0	16095	0	16095
VARIOUS LOCATIONS (a)	0	0	0	0	0	[illegible]	0	[illegible]
AGENCY TOTAL	117199	1967807	1317086	2077	[illegible]	3091147	299769	7104737

596

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

SUMMARY

LYNDON B. JOHNSON SPACE CENTER

Office of Space Flight:	Amount	Page No.
Construction of Central Computing Facility	9,000,000	CF 1-1

LYNDON B. JOHNSON SPACE CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF CENTRAL COMPUTING FACILITY

LOCATION PLAN

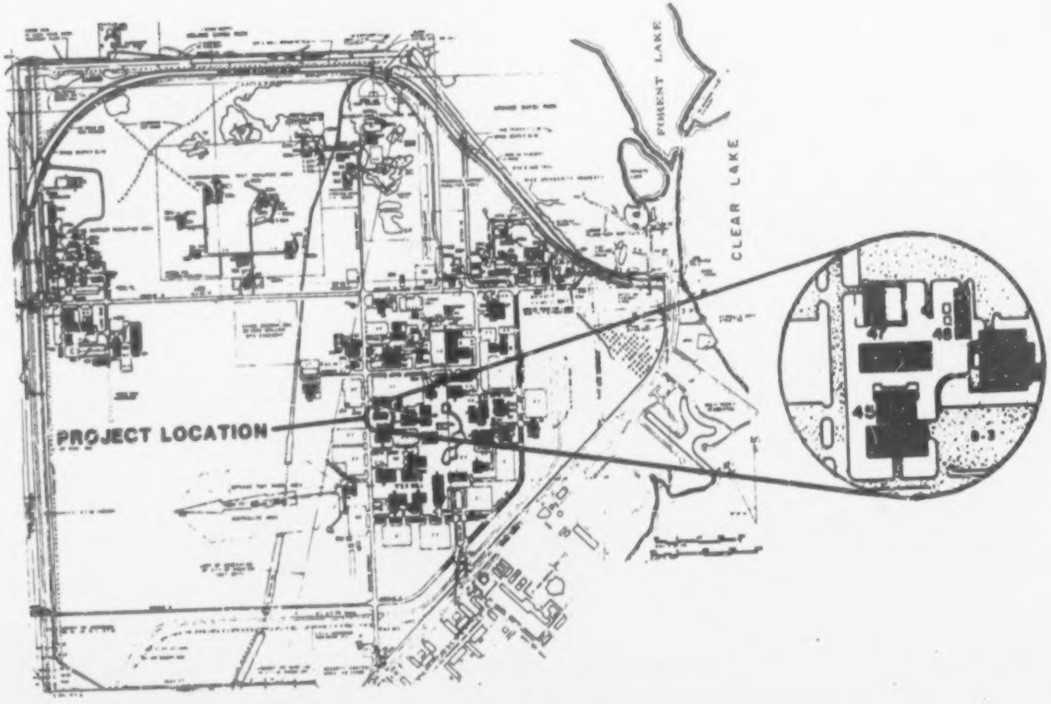

PROJECT LOCATION
FOREST LAKE
CLEAR LAKE
47
46
45
B-3

FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE: Construction of Central Computing Facility

INSTALLATION: Lyndon B. Johnson Space Center

FY 1987 CoF Estimate: $9,000,000

LOCATION OF PROJECT: Houston, Harris County, Texas

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding	740,000	---	740,000
Capitalized investment	N/A	---	---
Total	740,000	---	740,000

SUMMARY PURPOSE AND SCOPE:

This project provides for the construction of a 66,500-square foot facility to meet the immediate data processing requirements of the Johnson Space Center (JSC). All existing computer-related areas are fully utilized or over-extended. This new facility will provide the space to accommodate planned additional large-scale computer systems and support equipment to consolidate the center's administrative ADP functions; provide space for Space Shuttle engineering and development computers; and support the initial automated management information systems for the Space Station Program.

PROJECT JUSTIFICATION:

This project is required to house data processing systems growth resulting from requirements for productivity increases, project support expansion, and a need to consolidate scattered operations. Space Shuttle operations activities have consumed all available computer floor space, and the planned growth in computational capability to support future space flight operations can not be accommodated. Space Shuttle operations growth to support increased flight rates and productivity gains requires additional system dedication and isolation from other computing systems and functions. This requires that the multipurpose administrative, functional and engineering computing systems be relocated to other computer space. The Space Station program will also generate new automated information management and data systems requirements which will cause significant growth in research and engineering computational capacity. Space must be provided to accommodate this growth. This central computing facility will also provide a higher level of computer security than can be economically achieved in the existing computer space and locations.

The existing center computer floor space will continue to be utilized to consolidate Space Shuttle operations and dedicated research and engineering systems. However, the new computer building will permit relocation of functions such as the Space Shuttle software production system and will provide the physical separation and protection for critical Space Shuttle software processing systems. This will relieve serious overcrowding in existing computer space and result in a much improved and more efficient layouts.

The new facility will also provide space for expansion of JSC automated administrative functions and will enhance centerwide productivity through computational systems growth that cannot be accomplished in existing space. Additional computer space is also essential for initial efforts in support of the Space Station's automated information management and data systems. The new computing facility will provide for the above near term requirements for computer floor space.

IMPACT OF DELAY:

Delay of this project will mean that space and supporting utilities will not be available for new computer equipment that JSC will be receiving in 1988. Without suitable housing, this equipment will not be able to support critical Shuttle operations functions and will not be available for initial Space Station computational and technical support. It is most essential that this additional computer space be provided at this time.

PROJECT DESCRIPTION:

This project provides for the construction of a three-story steel framed building of approximately 66,500 square feet of floor space on the east side of Second Street, north of Building 45 (Figure 1). Site work will include the construction of a connecting tunnel to the JSC utility tunnel system, storm drainage, sanitary sewer, waterlines, communications, and a service drive with parking. The building (Figure 2) will include three access zones for computer security, approximately 47,000 square feet of raised computer floor area, and office space. Also included is a tape library, operations support areas, an elevator with a load capacity of 10,000 pounds, and a loading dock. Electrical power, cooling, lighting, communications, fire detection and alarm and suppression equipment to support large scale computer systems will be provided.

PROJECT COST ESTIMATE:

This cost estimate is based on a preliminary engineering report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	9,000,000
Site work, utilities, and paving	LS	---	---	560,000
Structural	SF	66,500	42.26	2,810,000
Architectural	SF	66,500	30.23	2,010,000
Electrical	SF	66,500	20.15	1,340,000
Mechanical	SF	66,500	34.28	2,280,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				9,000,000

LIST OF RELATED GRAPHICS:

Figure 1 - Project Location
Figure 2 - Central Computing Facility

OTHER EQUIPMENT SUMMARY:

Computers and other electronic data processing equipment of approximately $32,700,000 will be provided by R&D funds.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

No future CoF funding is required to complete this project. Present planning of computer system growth indicate that a comparably-sized building addition may be required in the future.

LYNDON B. JOHNSON SPACE CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF CENTRAL COMPUTING FACILITY

CENTRAL COMPUTING FACILITY

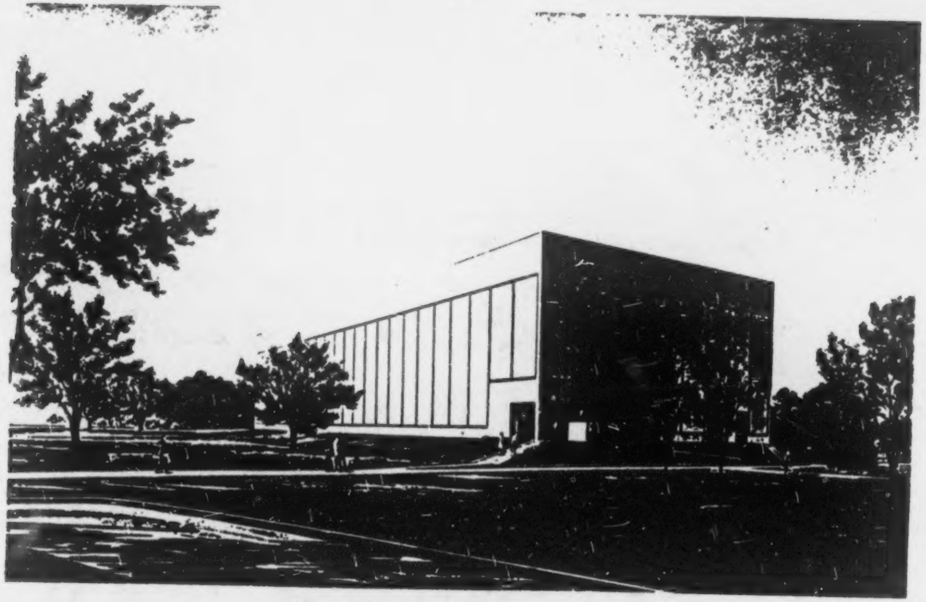


FIGURE 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

SUMMARY

SPACE STATION FACILITIES

Office of Space Station:	Amount	Page No.
Construction of Addition to the Systems Integration and Mockup Laboratory, Johnson Space Center	5,000,000	CF 2-1
Construction of Power Systems Facility, Lewis Research Center	5,800,000	CF 2-8
Modifications to Test Stand 300 for Space Station Hydrogen/Oxygen Propulsion Systems Development, Marshall Space Flight Center	2,100,000	CF 2-15
Total	12,900,000	

JOHNSON SPACE CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF ADDITION TO THE SYSTEMS INTEGRATION AND MOCKUP LABORATORY

LOCATION PLAN

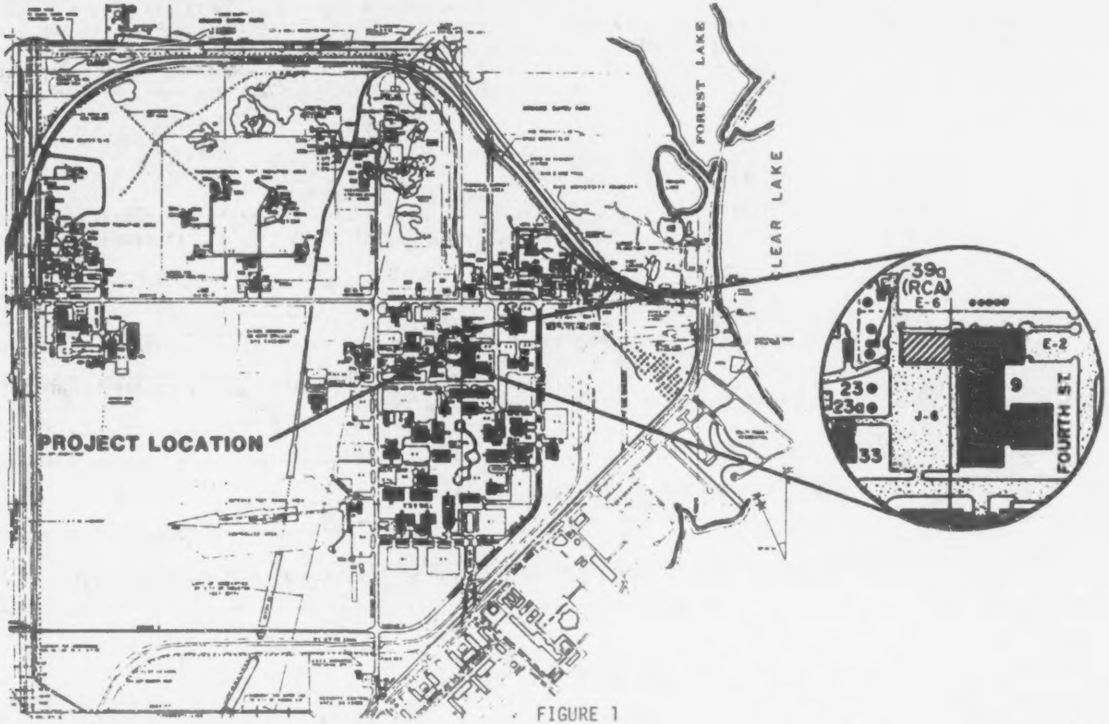

FOREST LAKE
LEAR LAKE
PROJECT LOCATION
39a
(RCA)
E-6
E-2
9
FOURTH ST.
23
23a
J-6
33

FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE:	Construction of Addition to the Systems Integration and Mockup Laboratory
INSTALLATION:	Lyndon B. Johnson Space Center
FY 1987 CoF Estimate:	$5,000,000

LOCATION OF PROJECT: Houston, Harris County, Texas

COGNIZANT HEADQUARTERS OFFICE: Office of Space Station

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding......................	440,000	---	440,000
Capitalized investment....................	N/A	5,220,000	5,220,000
Total.................................	440,000	5,220,000	5,660,000

SUMMARY PURPOSE AND SCOPE:

This project provides for the construction of an addition to the Systems Integration and Mockup Laboratory, Building 9, to house the Space Station large scale mockups and trainers. Approximately 20,600 square feet of high bay and 6,000 square feet of one-story support area will be added. It is essential that this space be provided now so that critical system integration and development can be accomplished to support the initial operational capability (IOC) of the Space Station.

PROJECT JUSTIFICATION:

The Space Station hardware will be constructed in space without it ever having been completely assembled on Earth. This unique approach requires that extensive systems engineering and integration capabilities be provided on the ground. To provide this capability, an extensive system of mockups and trainers is required. Presently, facilities at JSC and at other NASA centers are being used for the early concept development phases of the program, but it is essential that eventually this work be brought together in a central location so that proper detailed integration can be achieved. As the program progresses, higher fidelity mockups and trainers will be needed to develop and evaluate hardware and procedures. Integration of the Space Station, Mobile Remote Manipulator System and the Shuttle is another function that must be performed using the mockups and trainers that will be housed in the facility.

Present facilities at JSC cannot accommodate the mockups, trainers and associated activities and personnel required for the Space Station. An addition to the Systems Integration and Mockup Laboratory of Building 9 is the most cost-effective means of providing the required high bay floor space and associated support areas. Extending the high bay allows the existing overhead cranes, high bay doors, and air-bearing floor to support the new requirements. The expanded facility will provide space for the Space Station Man-System Test Bed, (MSTB), an integrated Mobile Remote Manipulator Development Facility (MRMDF), associated mockups and test activities, and operations for development and verification of station assembly and resupply techniques. The MSTB will be used for interior architectural definition, habitability verification, maintainability evaluations, operations development, and fit checks. This will provide engineering evaluation of the Space Station mobile remote manipulator arm and control system. The MSTB and MRMDF will support the concept development, engineering definition operation support, and station growth analysis. This facility needs to be operational at the end of calendar year 1987 to support Space Station mockup and manipulator system delivery and engineering schedules.

IMPACT OF DELAY:

Delay of the project will result in inadequate space for the Man-Systems Test Bed, the Mobile Remote Manipulator Development Facility and associated mockup and test articles required by the Space Station development program. This will seriously affect the ability of the Space Station program to meet its initial operational capability (IOC).

PROJECT DESCRIPTION:

This project provides for the construction of a 26,600-square foot addition to the Systems Integration and Mockup Laboratory of Building 9 (Figure 1). Site development includes the relocation of underground utilities, construction of a concrete ramp on the west end of the addition, electrical power, and parking. The high bay addition of 20,600-square foot will be a steelframe structure with precast, exposed aggregate facing panels (Figure 2). Also included is a one-story steelframe addition of 6,000 square feet that will provide space for technical support, mechanical and electrical equipment, restrooms, and storage. Additional air-conditioning and heating, fire detection and suppression, electrical power and lighting will also be provided. Modifications to Building 9 include relocating the large access door to the west end of the addition and extending the rails for an existing 20-ton capacity traveling crane to be used in the high bay addition.

PROJECT COST ESTIMATE:

This cost estimate is based on a preliminary engineering report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	5,000,000
Site Preparation:	---	---	---	500,000
Utilities	LS	---	---	(50,000)
Concrete ramps and parking	LS	---	---	(300,000)
Electrical power	LS	---	---	(150,000)
High Bay Addition	---	---	---	3,400,000
Structural	LS	---	---	(2,420,000)
Mechanical	LS	---	---	(620,000)
Electrical	LS	---	---	(360,000)
Technical Support Addition	---	---	---	900,000
Architectural and structural	LS	---	---	(550,000)
Mechanical	LS	---	---	(230,000)
Electrical	LS	---	---	(120,000)
Modifications to Building 9	---	---	---	200,000
Architectural and structural	LS	---	---	(100,000)
Mechanical	LS	---	---	(90,000)
Electrical	LS	---	---	(10,000)

Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				5,000,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Exterior Perspective

OTHER EQUIPMENT SUMMARY:

Non-collateral equipment costing approximately $6,000,000 will be required.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

CoF resources may be required in the future to provide additional space to support related systems engineering and integration activities.

JOHNSON SPACE CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF ADDITION TO THE SYSTEMS INTEGRATION AND MOCKUP LABORATORY

EXTERIOR PERSPECTIVE

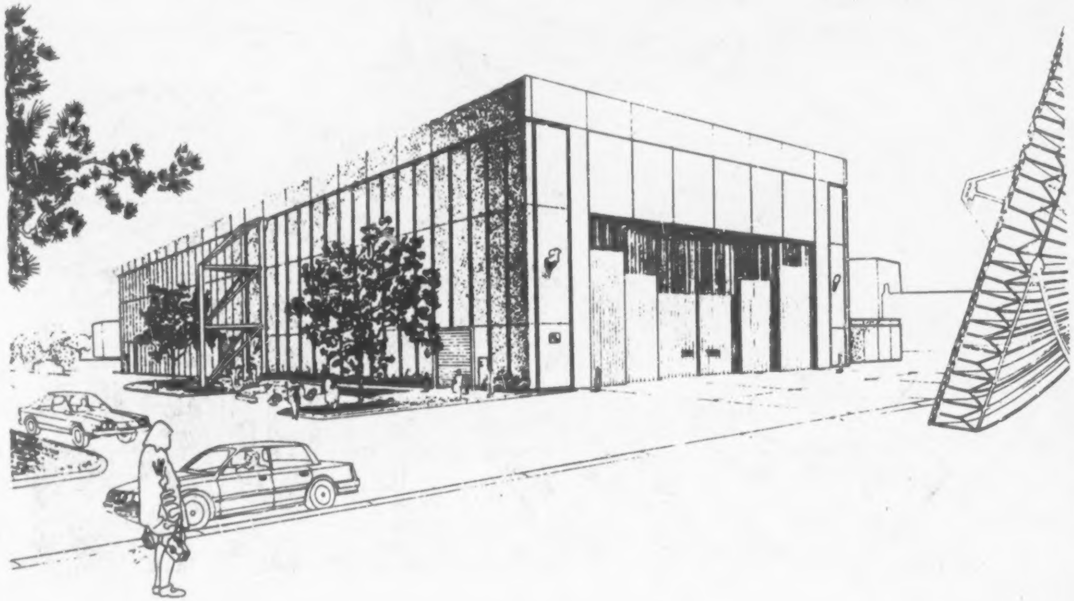


FIGURE 2

LEWIS RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF POWER SYSTEMS FACILITY

LOCATION PLAN

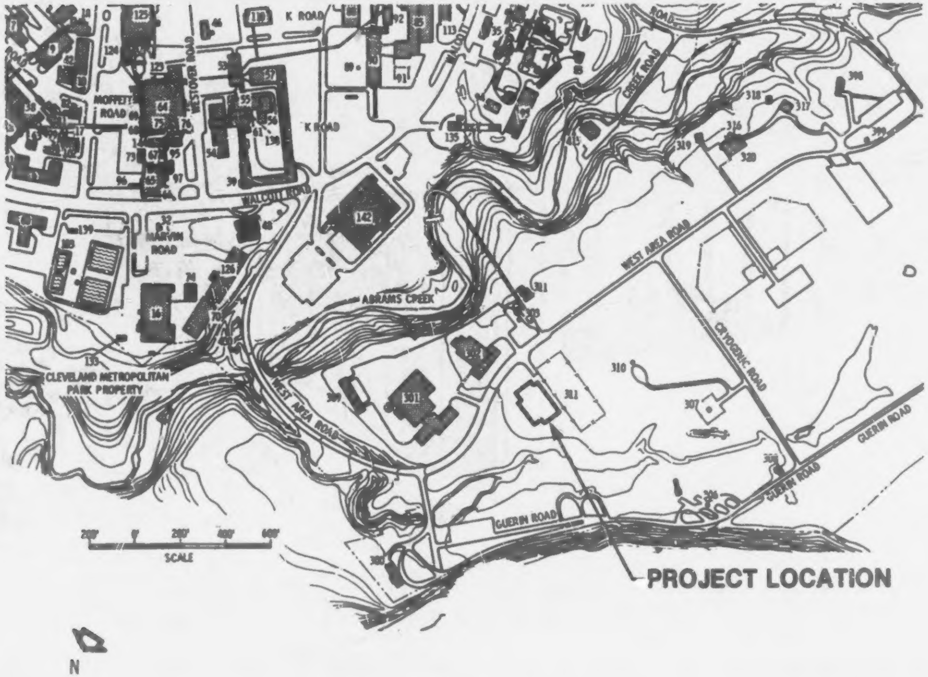

K ROAD
MOFFETT ROAD
K ROAD
WALCOTT ROAD
MARVIN ROAD
142
ABRAMS CREEK
CLEVELAND METROPOLITAN PARK PROPERTY
WEST AREA ROAD
WEST AREA ROAD
CRYOGENIC ROAD
GUERIN ROAD
GUERIN ROAD
GUERIN ROAD
301
311
310
307
200' 0 200' 400' 600'
SCALE
PROJECT LOCATION
N

FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE:	Construction of Power Systems Facility
INSTALLATION:	Lewis Research Center
FY 1987 CoF Estimate:	$5,800,000

LOCATION OF PROJECT: Cleveland, Cuyahoga County, Ohio

COGNIZANT HEADQUARTERS OFFICE: Office of Space Station

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding......................	460,000	—	460,000
Capitalized investment....................	N/A	—	—
Total..................................	460,000	—	460,000

SUMMARY PURPOSE AND SCOPE:

The Power Systems Facility (PSF) will provide the capability for development, testing and evaluation of prototype power systems hardware for the Space Station program. The facility will be used to test systems in support of the initial operational capability (IOC) and follow-on operational phases of the Space Station, simulate anomalies during flight, and support testing needs for future refinements. The PSF will have a total area of approximately 31,000 square feet and will include a high bay test area with Class 100,000 Clean Room capability, a loading-unloading-workshop area, laboratory rooms and support areas, and will be capable of testing both photovoltaic and solar dynamic power systems. Existing facilities were evaluated and determined to be inadequate for meeting the power systems hardware development and testing requirements.

PROJECT JUSTIFICATION:

The power system for the Space Station, which may be photovoltaic or solar dynamic or a hybrid of both, will be the largest and most complex ever launched into space. Because of its size and complexity, and also because it is essential to develop and thoroughly test such a power system to satisfy the stringent requirements for long duration operations in space, a Power Systems Facility is needed to provide the space capability and cleanliness required for critical development and performance verification. Testing will be done on engineering and initial flight models. Interactions among the power generation, storage, management, and distribution components, and transient behavior of the full system during normal and abnormal conditions will also be determined in the facility using full-sized system configurations.

The PSF will have the capability to test both the photovoltaic and solar dynamic systems. An initial flight photovoltaic solar array will be deployed in the high-bay area, illuminated with lights simulating the sun, and tested with the regenerative fuel cell or battery storage subsystem. Solar dynamic systems will be tested with electrical heat simulating solar heat and tested together with the power management and distribution system. Assembly/deployment tests, optical tests, and vibration tests of concentrating mirrors as large as 60 feet in diameter will be conducted in the clean high-bay area.

The building site (Figure 1) has been selected for its close proximity to the existing solar array field in recognition of the importance of using line lengths representative of the Space Station electrical power distribution system. Electrical transient interactions are very sensitive to line lengths and component separation as well as the detailed characteristics of the power source. While some studies will be done using the solar simulator others will require use of the outside solar array powered by the sun.

Power system testing in the PSF will support the development phase for the initial operational capability (IOC) of the Space Station, and the investigation of problems encountered during station operation, aid in the integration of payloads with special power needs, and support the development and verification of power system modifications and additions as the Space Station matures.

The PSF will replace inadequate trailers that are now used as the Space Station Power Test Bed for advanced development testing. Also, the present accommodations do not provide adequate assembly/repair shop areas, regenerative fuel cell test area, room for discrete and customized loads, high-bay areas for testing of flight-type arrays and for disassembly and tests of concentrators for solar dynamic power systems.

IMPACT OF DELAY:

This project is needed now to support the development design of the Space Station in time for the initial operational capability (IOC). Delay would result in the power system research and development being performed in undersized and inadequate facilities that would significantly compromise the development of this critical element of the Space Station.

PROJECT DESCRIPTION:

This project will provide a new PSF, with a floor area of approximately 31,000 square feet, located in the LeRC West Area (Figure 2) near the existing solar array field. The PSF will consist of a 10,300-square foot high bay test area approximately 45 feet high with Class 100,000 Clean Room capability (Figure 3). Adjacent to this test area will be a 2,300-square foot loading-unloading-workshop area. The test area and the loading-unloading-workshop area will each be provided with 10-ton overhead cranes to facilitate test build-up and equipment handling. Supporting laboratory areas, consisting of 6,500 square feet, will include a battery room, solar dynamics laboratory and simulator, electrical load, control, and computer rooms, controls laboratory and software support center, power processing laboratory, terminal room, fuel cells and simulator room, and a vacuum tank area. The remaining 11,900 square feet will be general support area. Standard utility services of water, steam, service air, electrical power, communication, and safety systems will also be provided.

PROJECT COST ESTIMATE:

This cost estimate is based on a preliminary engineering report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	5,800,000
Site development/utilities	LS	---	---	362,000
Building	SF	31,000	169.77	5,263,000
Special features (cranes)	LS	---	---	175,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				5,800,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - First Floor Plan

OTHER EQUIPMENT SUMMARY:

R&D funded noncollateral equipment costing approximately $2,700,000 will be provided. Included are items such as computers, data acquisition systems, instrumentation, batteries, controllers and related test equipment.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

No future CoF funding will be required to complete this project.

LEWIS RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF POWER SYSTEMS FACILITY

SITE PLAN

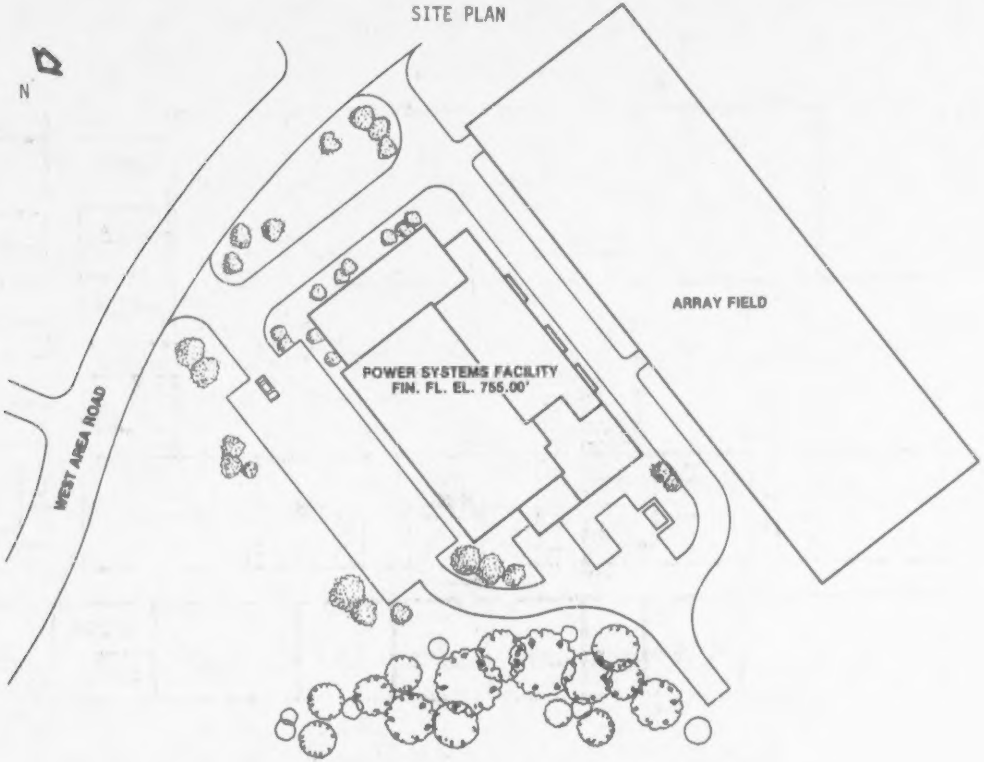

N
ARRAY FIELD
POWER SYSTEMS FACILITY
FIN. FL. EL. 755.00'
WEST AREA ROAD

FIGURE 2

LEWIS RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF POWER SYSTEMS FACILITY

FIRST FLOOR PLAN

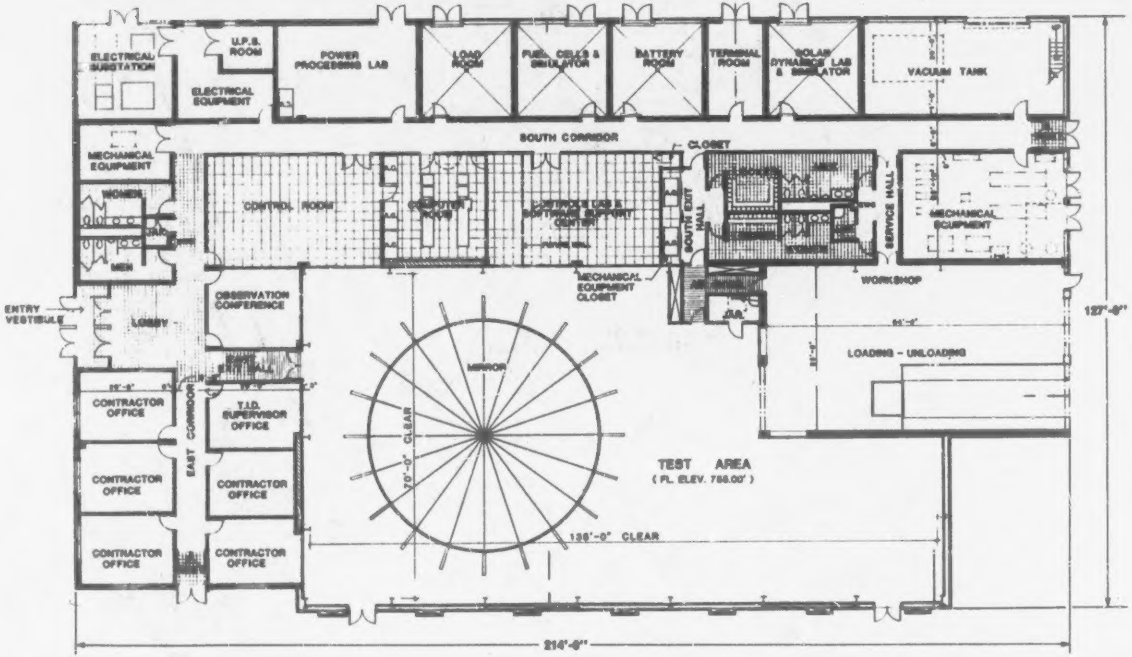

ELECTRICAL SUBSTATION
U.P.S. ROOM
ELECTRICAL EQUIPMENT
POWER PROCESSING LAB
LOAD ROOM
FUEL CELLS & SIMULATOR
BATTERY ROOM
TERMINAL ROOM
SOLAR DYNAMICS LAB & SIMULATOR
VACUUM TANK
SOUTH CORRIDOR
CLOSET
MECHANICAL EQUIPMENT
WOMEN
MEN
CONTROL ROOM
COMPUTER ROOM
CONTROLS LAB & SOFTWARE SUPPORT CENTER
SOUTH EXIT HALL
SERVICE HALL
MECHANICAL EQUIPMENT
MECHANICAL EQUIPMENT CLOSET
WORKSHOP
ENTRY VESTIBULE
LOBBY
OBSERVATION CONFERENCE
EAST CORRIDOR
CONTRACTOR OFFICE
T.I.D. SUPERVISOR OFFICE
CONTRACTOR OFFICE
CONTRACTOR OFFICE
CONTRACTOR OFFICE
CONTRACTOR OFFICE
MIRROR
70'-0" CLEAR
LOADING - UNLOADING
TEST AREA
(FL. ELEV. 766.00')
135'-0" CLEAR
127'-0"
214'-0"

FIGURE 3

MARSHALL SPACE FLIGHT CENTER
FISCAL YEAR 1987 ESTIMATES
MODIFICATIONS TO TEST STAND 300 FOR SPACE STATION HYDROGEN/OXYGEN
PROPULSION SYSTEMS DEVELOPMENT

LOCATION PLAN

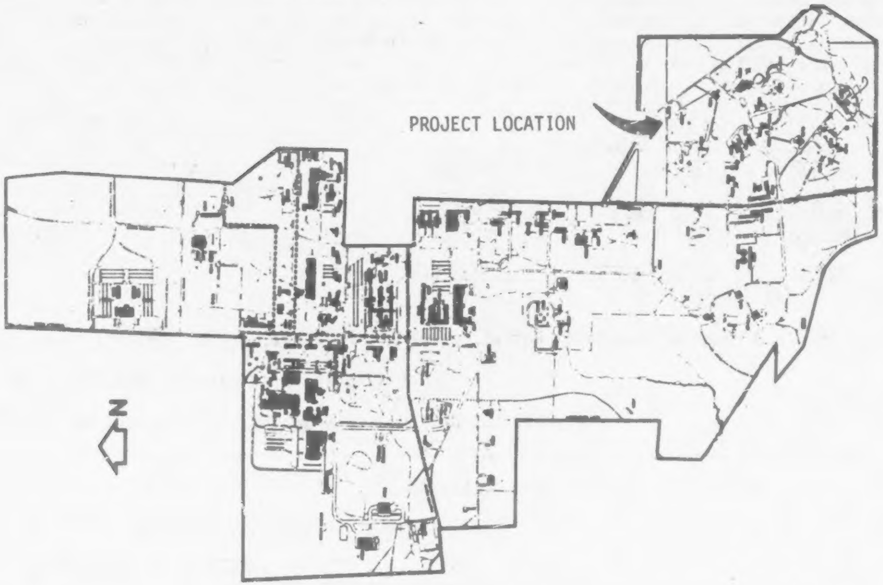


FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE: Modifications to Test Stand 300 for Space Station Hydrogen/Oxygen Propulsion Systems Development

INSTALLATION: George C. Marshall Space Flight Center

FY 1987 CoF Estimate: $2,100,000

LOCATION OF PROJECT: Marshall Space Flight Center, Madison County, Alabama

COGNIZANT HEADQUARTERS OFFICE: Office of Space Station

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding......................	192,000	---	192,000
Capitalized investment....................	N/A	1,200,000	1,200,000
Total..................................	192,000	1,200,000	1,392,000

SUMMARY PURPOSE AND SCOPE:

This project modifies Test Stand 300 at Marshall Space Flight Center (MSFC) for testing of the integrated propulsion systems of relatively low thrust in the range of a few pounds to a few hundred pounds at simulated altitude and thermal conditions. The existing propulsion system technology employs hydrazine fuels. The goal of the advanced development program is to provide technology which will employ fuels of higher specific energy, such as LOX/H_2, with minimal environmental contamination. To develop and test these oxygen/hydrogen propulsion systems, a test stand capable of providing orbital vacuum simulation, handling of cryogens, and allowing propellant flow and start testing is required. Test Stand 300, with the modifications provided by this project, can best provide these capabilities.

PROJECT JUSTIFICATION:

This development program has as its aim, bringing the high performance oxygen-hydrogen propellant concept to a level of maturity commensurate with current systems. The use of propulsion systems employing high efficiency oxygen and hydrogen fuels on the Space Station will lead to a significant reduction in life cycle costs because of the reduced amount of propellant that will have to be transported from earth. These oxygen/hydrogen propellant systems will also reduce the environmental contamination due to fuel residue resulting from the present systems. Environmental contaminations would reduce the utility of the Space Station for scientific applications which require the cleanest possible local viewing conditions for optical instruments.

MSFC is the lead center for Space Station propulsion activities with responsibility for full systems development and testing. These activities include the development of systems hardware and operational techniques for the use of oxygen and hydrogen fluid systems. Systems components such as tanks, thrusters, lines, and controls will be developed at other centers or at contractor facilities. All of these prototype components must be tested as a complete system. In addition, the system testing must be operated in a relevant environment. Tests will include start transients, venting and fuel flow, thermal testing of distributed fuel systems, and insulation performance. Test Stand 300 will be modified to provide this capability for Space Station propulsion tests at simulated altitude and thermal conditions. To support high performance propulsion systems tests the 20-foot diameter space vacuum chamber will require additional vacuum pumping capability to sustain orbital altitude conditions with additional cryogenic cold walls, liquid hydrogen, oxygen and nitrogen storage capacity, expanded electrical power, instrumentation, controls and safety equipment. These modifications must be completed in 1988 to permit timely testing of prototype components, development hardware, and protoflight hardware for the Space Station.

IMPACT OF DELAY:

Delay of this project will prevent the timely development of an integrated propulsion system for the Space Station. This facility must be operational in 1988 to receive initial prototype component deliveries under the Space Station advanced development program. Time is needed to accumulate and analyze performance data prior to the launch of the first Space Station elements.

PROJECT DESCRIPTION:

This project will modify Test Stand 300, site 4530 (Figure 1) to include the addition of a 48-inch diffusion pump and isolation valve, a stainless steel low temperature cryogenically cooled thermal shroud in the 20-foot diameter space vacuum chamber and other related work (Figure 2). Work also includes relocation of an existing 35,000-gallon liquid hydrogen dewar and a 14,000 gallon liquid nitrogen dewar. It also includes vacuum jacketed piping, pumps, and related cryogenic transfer equipment for oxygen, hydrogen, and nitrogen. Electrical modification includes the installation of new data acquisition equipment, remote controls, instrumentation, electrical power and fireprotection systems. The project will also provide modifications for instrumentation systems in the test control and data recording centers.

PROJECT COST ESTIMATE:

The project cost estimate is based on a preliminary engineering report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	2,100,000
Mechanical	---	---	---	1,260,000
Diffusion pump and piping	LS	---	---	(210,000)
Cryo panels and piping	LS	---	---	(330,000)
Rehabilitate 20-foot diameter chamber	LS	---	---	(90,000)
Cryogenic tanks and equipment	LS	---	---	(630,000)
Electrical	---	---	---	780,000
Data acquisition system	LS	---	---	(430,000)
Controls	LS	---	---	(50,000)
Instrumentation	LS	---	---	(110,000)
Electrical power equipment	LS	---	---	(190,000)
Architectural/Structural	LS	---	---	60,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				2,100,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan

OTHER EQUIPMENT SUMMARY:

No other equipment is required to complete this project.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

No future CoF funding is required to complete this project.

MARSHALL SPACE FLIGHT CENTER
FISCAL YEAR 1987 ESTIMATES
MODIFICATIONS TO TEST STAND 300 FOR SPACE STATION HYDROGEN/OXYGEN PROPULSION SYSTEMS DEVELOPMENT

SITE PLAN

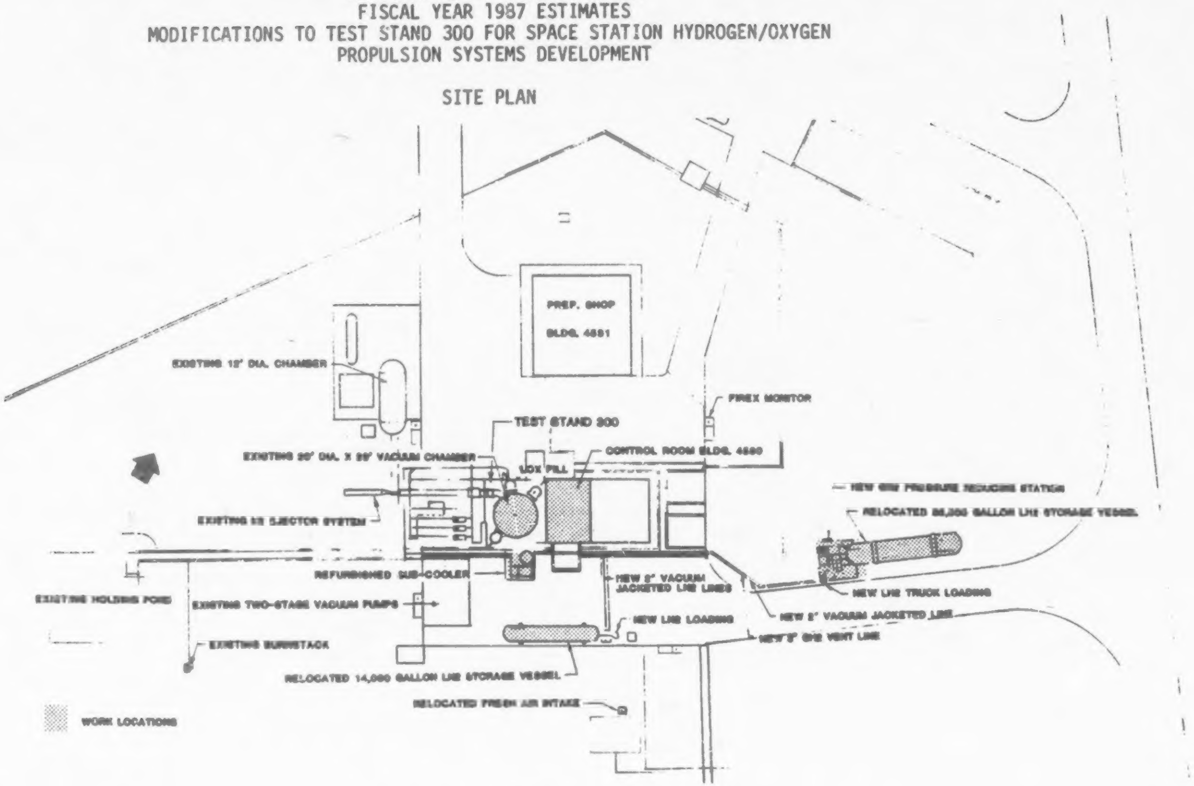

PREP. SHOP
BLDG. 4651
EXISTING 12' DIA. CHAMBER
FIREX MONITOR
TEST STAND 300
EXISTING 20' DIA. X 28' VACUUM CHAMBER
CONTROL ROOM BLDG. 4650
LOX FILL
NEW GN2 PRESSURE REDUCING STATION
EXISTING SS EJECTOR SYSTEM
RELOCATED 28,000 GALLON LH2 STORAGE VESSEL
REFURBISHED SUB-COOLER
NEW 2" VACUUM JACKETED LH2 LINES
NEW LH2 TRUCK LOADING
EXISTING HOLDING POND
EXISTING TWO-STAGE VACUUM PUMPS
NEW LH2 LOADING
NEW 2" VACUUM JACKETED LINE
NEW 3" GH2 VENT LINE
EXISTING BURNSTACK
RELOCATED 14,000 GALLON LH2 STORAGE VESSEL
RELOCATED FRESH AIR INTAKE
WORK LOCATIONS

FIGURE 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

SUMMARY

SPACE FLIGHT FACILITIES

Office of Space Flight:	Amount	Page No.
Construction of Addition to Orbiter Processing Facility Annex, Kennedy Space Center	3,400,000	CF 3-1

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF ADDITION TO ORBITER PROCESSING FACILITY ANNEX

LOCATION PLAN

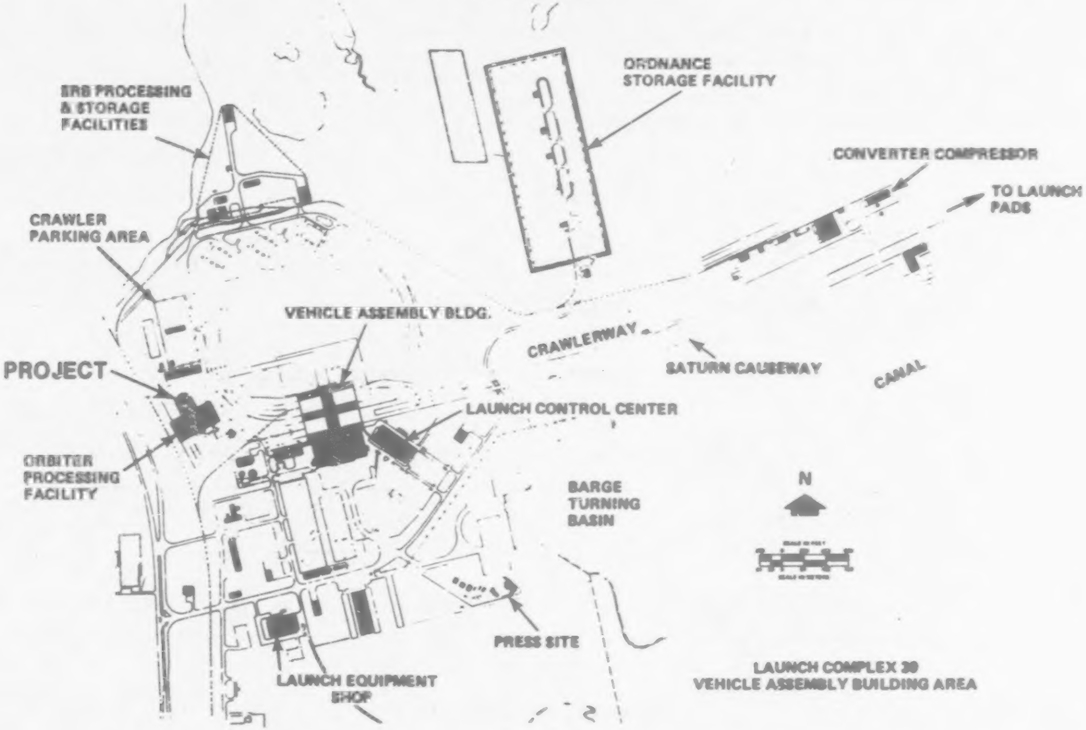

SRB PROCESSING & STORAGE FACILITIES
ORDNANCE STORAGE FACILITY
CONVERTER COMPRESSOR
TO LAUNCH PADS
CRAWLER PARKING AREA
VEHICLE ASSEMBLY BLDG.
CRAWLERWAY
SATURN CAUSEWAY
CANAL
PROJECT
LAUNCH CONTROL CENTER
ORBITER PROCESSING FACILITY
BARGE TURNING BASIN
N
PRESS SITE
LAUNCH EQUIPMENT SHOP
LAUNCH COMPLEX 39
VEHICLE ASSEMBLY BUILDING AREA

FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE: Construction of Addition to Orbiter Processing Facility Annex

INSTALLATION: John F. Kennedy Space Center

FY 1987 CoF Estimate: $3,400,000

LOCATION OF PROJECT: John F. Kennedy Space Center, Brevard County, Florida

COGNIZANT HEADQUARTERS OFFICE: Office of Space Flight

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding......................	337,000	---	337,000
Capitalized investment....................	N/A	36,321,257	36,321,257
Total..................................	337,000	36,321,257	36,658,257

SUMMARY PURPOSE AND SCOPE:

This project provides for the construction of a three-story addition to the annex of the Orbiter Processing Facility (OPF) for adequate support space for the operational processing of the Space Transportation System (STS) Orbiter. It consists of approximately 36,000 square feet with the first floor providing a central marshalling/locker area for technical and quality control personnel, and the second and third floors housing OPF support personnel. This project eliminates the existing trailers north and west of the annex, now used by personnel involved in Orbiter processing.

PROJECT JUSTIFICATION:

As the Space Shuttle continues into the operational era, around-the-clock processing will be taking place in both bays of the OPF. Early estimates of the nature and amount of work required to deservice and process an Orbiter between flights were underestimated. Almost four years of experience have clearly shown that Orbiter turnaround will continue to be a labor intensive, time-critical operation, requiring many technicians and quality control personnel.

The nearly 1,000 technicians and quality control personnel associated with operations in the OPF are currently housed in and operate from substandard temporary facilities. Since basic locker rooms, rest rooms, and eating facilities were not provided in the original facility, trailers and vans have been brought on site for lunch/vending areas, rest rooms, flight hardware and ground support equipment (GSE) storage, and offices. Portable latrine facilities are in use both northwest and west of the facility. Hallways are being used for storage and shop space; several small annex rooms have been turned into offices or engineering support space; and the outside areas adjacent to the OPF are of necessity, frequently used for additional shop and storage space when the weather permits. These crowded and undesirable working conditions cannot sustain the quality of performance and efficient processing needed for an operational orbiter fleet. This project eliminates the need for the existing trailer complex north of the Annex and the trailers and port-o-lets west of the OPF, eliminating a total of 36 trailers. This project also allows for the relocation of nonessential personnel from the hazardous environment of the existing high bays to more suitable accommodations.

IMPACT OF DELAY:

Deferral will result in continued inefficiencies due to use of the temporary, substandard and inadequate accommodations for the OPF personnel, equipment and flight hardware and deter the enhanced effectiveness needed to attain planned program flight rate objectives.

PROJECT DESCRIPTION:

This project provides for the construction of a three-story addition to the OPF Annex of approximately 36,000 square feet with an enclosed walkway between the addition and the OPF low bay. The air-conditioned building will be of steel frame and concrete masonry construction, providing space on the first floor for marshalling and locker areas, technicians, and quality control personnel. The second and third floors will be built in an open engineering space concept for housing OPF support personnel. Tie-ins to existing utilities, restrooms, and a lunch/vending area for personnel associated with Orbiter processing at the OPF will also be included.

PROJECT COST ESTIMATE:

This cost estimate is based on a preliminary engineering report (PER).

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	3,400,000
Site development & utilities	SY	3,245	58.55	190,000
Temporary trailer relocations	EA	24	8,958.00	215,000
Building/structural	SF	36,000	77.86	2,803,000
Special features	LS	1	---	192,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				3,400,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - Perspective

OTHER EQUIPMENT SUMMARY:

Non-collateral equipment such as systems furniture and communications equipment will be funded from $800,000 of R&D resources.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

No future CoF funding will be required to complete this project.

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF ADDITION TO ORBITER PROCESSING FACILITY ANNEX

SITE PLAN

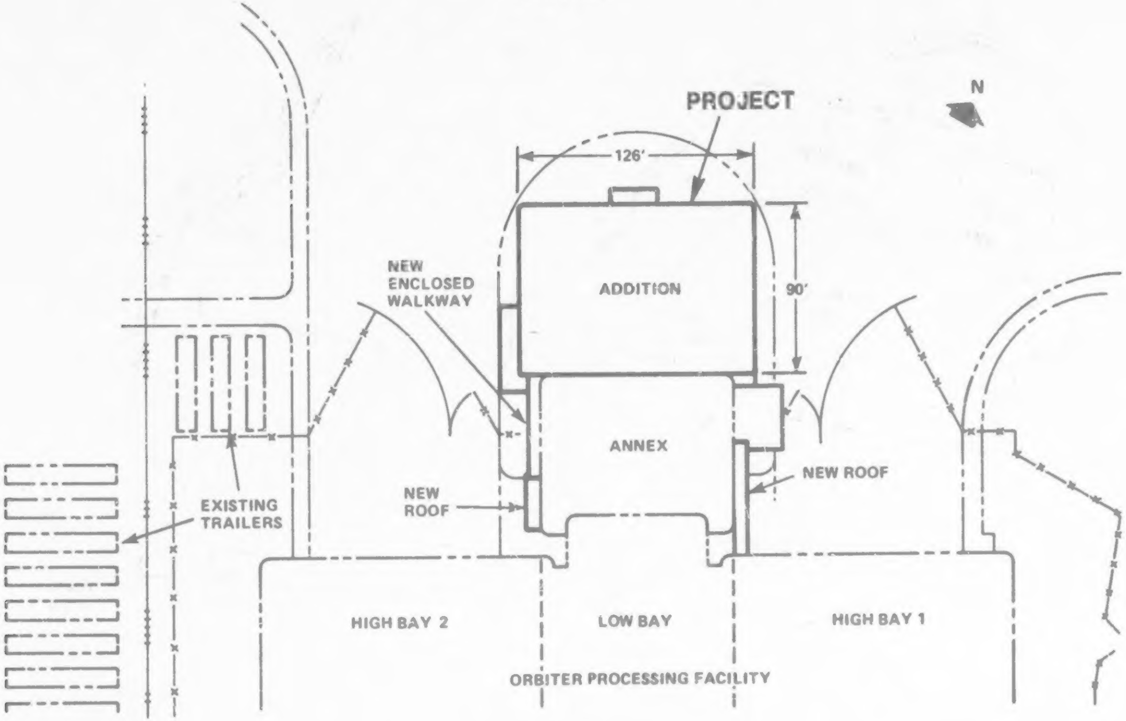

PROJECT
N
126'
90'
ADDITION
NEW ENCLOSED WALKWAY
ANNEX
NEW ROOF
NEW ROOF
EXISTING TRAILERS
HIGH BAY 2
LOW BAY
HIGH BAY 1
ORBITER PROCESSING FACILITY

FIGURE 2

JOHN F. KENNEDY SPACE CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF ADDITION TO ORBITER PROCESSING FACILITY ANNEX
PERSPECTIVE

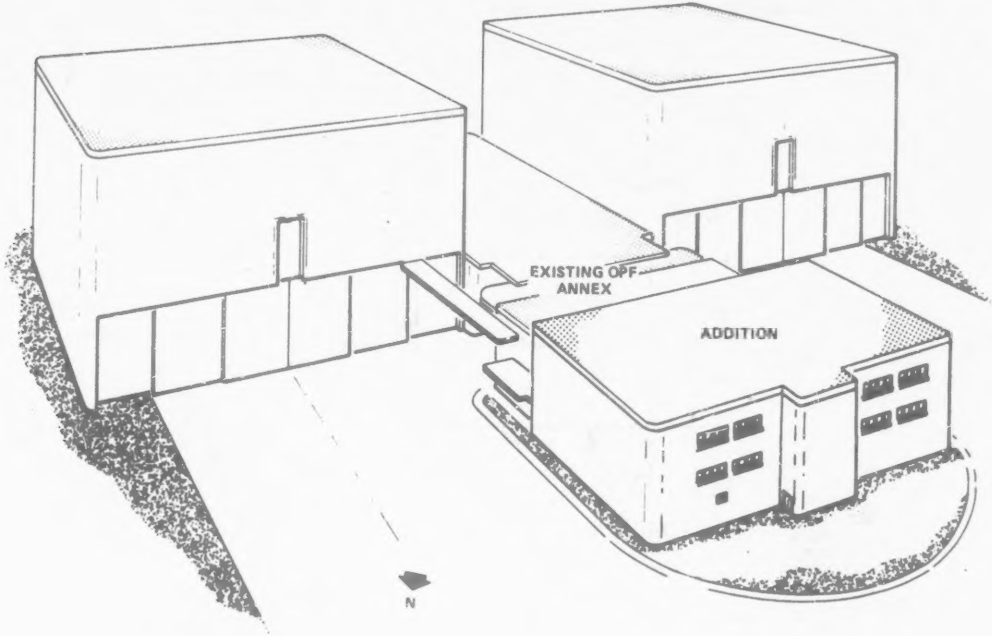

EXISTING OPF ANNEX
ADDITION
N

FIGURE 3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

SUMMARY

GODDARD SPACE FLIGHT CENTER

Office of Space Science and Applications:	Amount	Page No.
Construction of Spacecraft Systems Development and Integration Facility.........	8,000,000	CF 4-1

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF SPACECRAFT SYSTEMS DEVELOPMENT AND INTEGRATION FACILITY

LOCATION PLAN

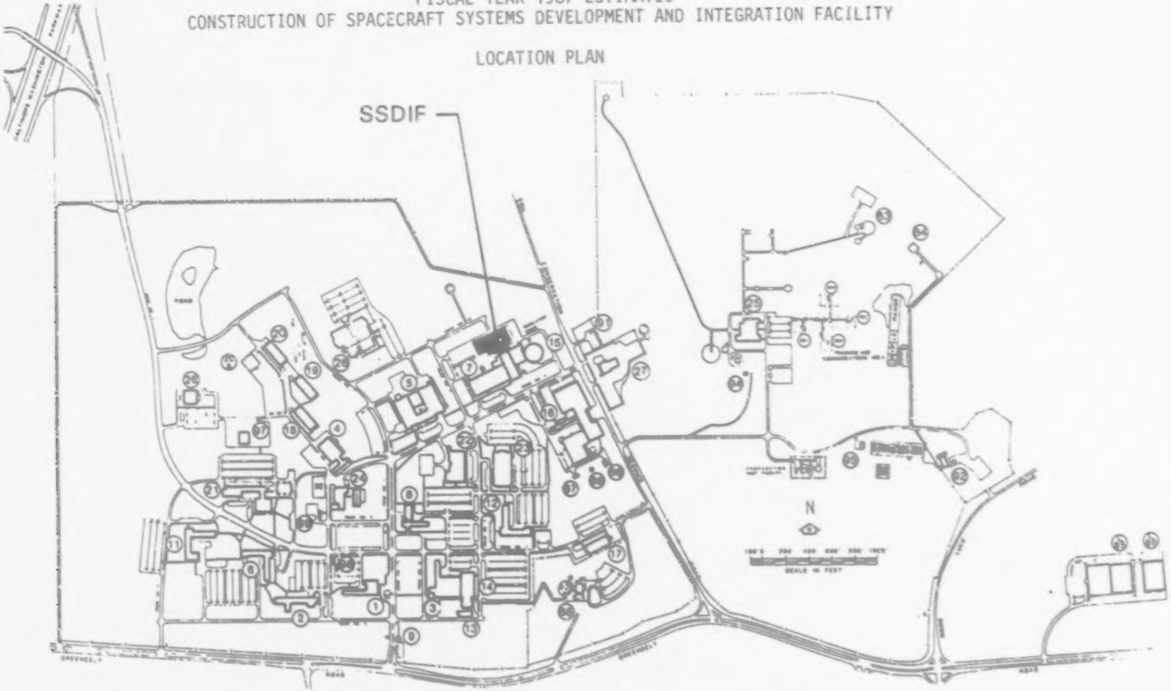


FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE: Construction of Spacecraft Systems Development and Integration Facility

INSTALLATION: Goddard Space Flight Center

FY 1987 CoF Estimates: $8,000,000

LOCATION OF PROJECT: Greenbelt, Prince George's County, Maryland

COGNIZANT HEADQUARTERS OFFICE: Office of Space Science and Applications

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding......................	1,100,000	---	1,100,000
Capitalized investment....................	N/A	---	---
Total..................................	1,100,000	---	1,100,000

SUMMARY PURPOSE AND SCOPE:

This project provides the first increment of construction of an addition to the Building 7/10/15 complex to provide a Spacecraft Systems Development and Integration Facility. This facility will accommodate simultaneous multi-year development and integration, and/or major long term refurbishment of two spacecraft, each up to the size of a full shuttle payload, in a work space equipped with requisite stringent environmental controls. Present GSFC facilities are too small for full size shuttle payloads, and the high throughput prelaunch processing facilities at the Kennedy Space Center are not intended nor available for this longer term work. The second and final increment to complete the facility is planned for FY 1988.

PROJECT JUSTIFICATION:

With the Space Shuttle now operational, full exploitation of its capabilities to support space science and applications missions is being initiated through planning and development of larger and heavier spacecraft and payloads. Shuttle-launched spacecraft with larger and expanded instrumentation are expected to play a significant role in increasing our understanding of the universe and the earth. When it is economically or scientifically advantageous, these highly instrumented spacecraft can now be designed to capitalize on the flexibility of retrieval and refurbishment for extended useful life and reuse. GSFC is the appropriate site for the development of these large instruments because it is the lead center for the development, fabrication, integration, and management of science and applications spacecraft in earth orbit. GSFC also possesses the required personnel that are skilled in the related state-of-the-art technology. To fully use this valuable and resident expertise requires the provision of an integration and fabrication facility large enough to accommodate maximum size shuttle flight hardware.

Construction of this facility as an addition to the GSFC spacecraft development complex will provide the capability for processing and integrating spacecraft up to Shuttle payload bay capability, and take advantage of existing support systems. The first elements of the existing facility complex were designed and constructed in the early 1960's to accommodate sounding rockets, Explorers, and other small spacecraft. The facilities were expanded in 1967 to provide for integration of spacecraft for Delta and Centaur sized launch vehicles, and again in 1978 to accommodate shuttle pallet sized instruments of up to 10,000 pounds maximum weight. These GSFC integration and test facilities can be used for major component work, in support of Shuttle-size spacecraft, but current size and weight limitations prevent work on the large flight hardware that can take full advantage of the Space Shuttle's capability. A high bay, laminar flow, clean room is the most critical element of this facility requirement. To meet the stringent requirements of scientific spacecraft and instruments, it must provide a cleanliness standard of class 100 as the air enters the room in order to ensure a class 10,000 environment at the work stations. It often requires up to two years for spacecraft development integration, encompassing physical and electromagnetic testing, functional testing, electronic and optical adjustment, and alignment. Based on current planning, the proposed facility must be able to accommodate the simultaneous integration and/or refurbishment of two spacecraft which permits necessary program overlaps.

The payload processing facilities at the Kennedy Space Center are not designed for and cannot accommodate this type of long term work. They are fully committed to prelaunch processing of shuttle payloads. Existing development contractor facilities do not meet the cleanliness, size and scheduling criteria. This facility will also significantly enhance GSFC's ability to retain and maintain the necessary in-house expertise in research, development, integration, and test activities.

IMPACT OF DELAY:

Delay of this project would adversely impact the full exploitation of the Shuttle's capabilities for NASA research and development spacecraft, by restricting spacecraft development to the present size and weight limited facilities. This facility must be started now in order that developmental spacecraft which can take full advantage of the large Shuttle cargo bay capability can be properly supported.

PROJECT DESCRIPTION:

This project will provide the initial increment of construction of a technical addition of approximately 78,800 gross square feet to the north side of the Building 7/10/15 complex (Figure 1). Long lead structural steel, foundations, some site work and closing in of the building shell will be emphasized during this phase of work. Domestic water, sanitary and storm sewers, communications, steam, chilled water, and electrical power are available and will be extended from existing distribution systems within the appropriate increments.

The facility addition (Figure 2) when completed will include: a 12,500-square foot, 106-foot high bay, laminar flow, clean room; a 1,000-square foot change room for personnel changing into cleanroom attire; a 25,000-square foot flight hardware storage area (includes 5,000 square feet of bonded storage area for long term storage of payload components); a 10,000-square foot two-story support area (includes a 3,500-square foot automatic data processing room for simulating data flow to and from payloads); and an 11,500-square foot staging, shipping and receiving area. This facility will be supported by the existing integration, environmental test, control centers, and data processing capability located in the adjacent Building 7/10/15 complex and elsewhere at GSFC.

The clean room is sized to simultaneously accommodate two full shuttle bay payloads up to 60 feet long, 15 feet in diameter and maximum Shuttle cargo weight. It will also house related ground support equipment and provide adequate access aisles. Two cranes will be installed within the clean room with hoisting capabilities of 35 tons each. Class 100 filtered air (90,000 cubic feet per minute) will enter the clean room at the north side through a floor-to-ceiling, wall-to-wall, high efficiency particulate air filter bank (Figure 3). This filtering system will produce a cleanliness level of at least class 10,000 within all work stations.

This facility will also include a 35-ton crane in the staging, shipping and receiving area; a passenger/freight elevator; a dual type electrical power system to provide redundancy; and a fire protection and utility control system which will be connected to the center wide utility control system.

PROJECT COST ESTIMATE:

This cost estimate is based on a preliminary engineering report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	8,000,000
Site development	LS	---	---	800,000
Demolition	LS	---	---	150,000
High bay laminar flow clean room	LS	---	---	4,000,000
Change room	LS	---	---	50,000
Flight hardware storage area	LS	---	---	900,000
Shipping, receiving, and staging area	LS	---	---	1,500,000
Automatic data processing and tech. suppt. area	LS	---	---	600,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				8,000,000

NOTE: This cost estimate provides only for the FY 1987 increment of the total facility. The total cost of the project is estimated to be approximately $16,000,000.

LIST OF RELATED GRAPHICS:

- Figure 1 - Location Plan
- Figure 2 - Floor Plans
- Figure 3 - Isometric Section
- Figure 4 - GSFC Spacecraft History 1960-1992

OTHER EQUIPMENT SUMMARY:

Materials handling equipment estimated to cost $50,000 will be provided from R&PM resources.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

To complete this project, a second and final increment will be included in the FY 1988 budget request for an approximately $8 million.

INTENTIONAL
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GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF SPACECRAFT SYSTEMS DEVELOPMENT AND INTEGRATION FACILITY

FLOOR PLAN

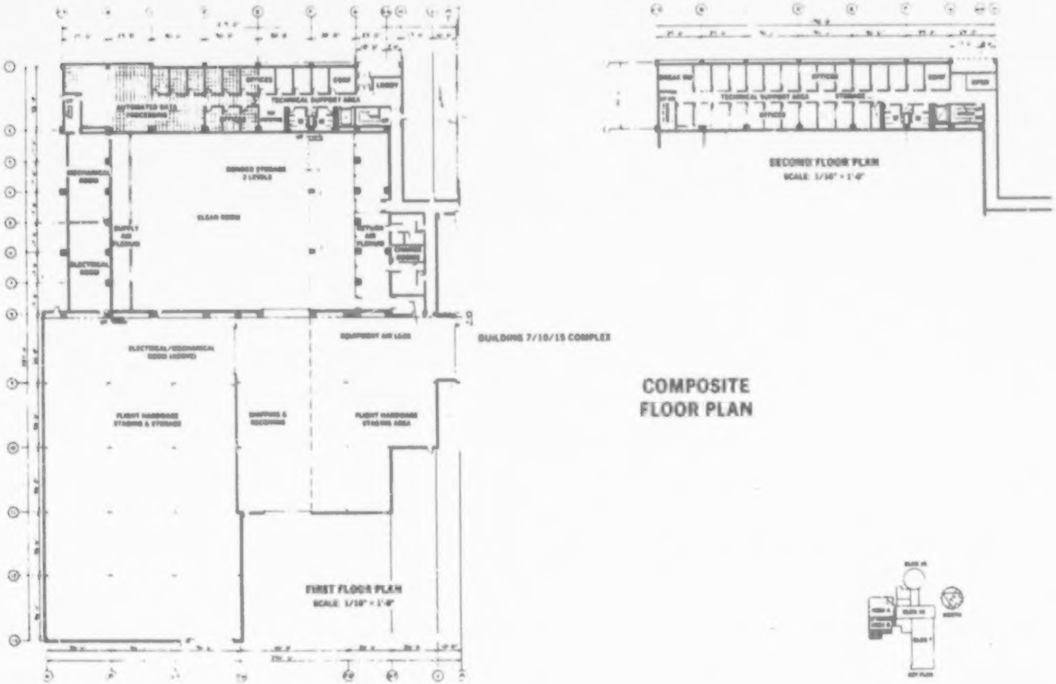
OFFICES
CONF
LOBBY
TECHNICAL SUPPORT AREA
AUTOMATED DATA PROCESSING
BONDED STORAGE 2 LEVELS
CLEAN ROOM
MECHANICAL ROOM
ELECTRICAL ROOM
SUPPLY AIR PLENUM
RETURN AIR PLENUM
CHANGE ROOMS
ELECTRICAL/MECHANICAL ROOM (ABOVE)
EQUIPMENT AIR LOCK
BUILDING 7/10/15 COMPLEX
FLIGHT HARDWARE STAGING & STORAGE
SHIPPING & RECEIVING
FLIGHT HARDWARE STAGING AREA
FIRST FLOOR PLAN
SCALE: 1/16" = 1'-0"
BREAK RM
OFFICES
CONF
OPEN
TECHNICAL SUPPORT AREA
STORAGE
OFFICES
SECOND FLOOR PLAN
SCALE: 1/16" = 1'-0"
COMPOSITE
FLOOR PLAN
KEY PLAN

FIGURE 2

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF SPACECRAFT SYSTEMS DEVELOPMENT AND INTEGRATION FACILITY

ISOMETRIC SECTION

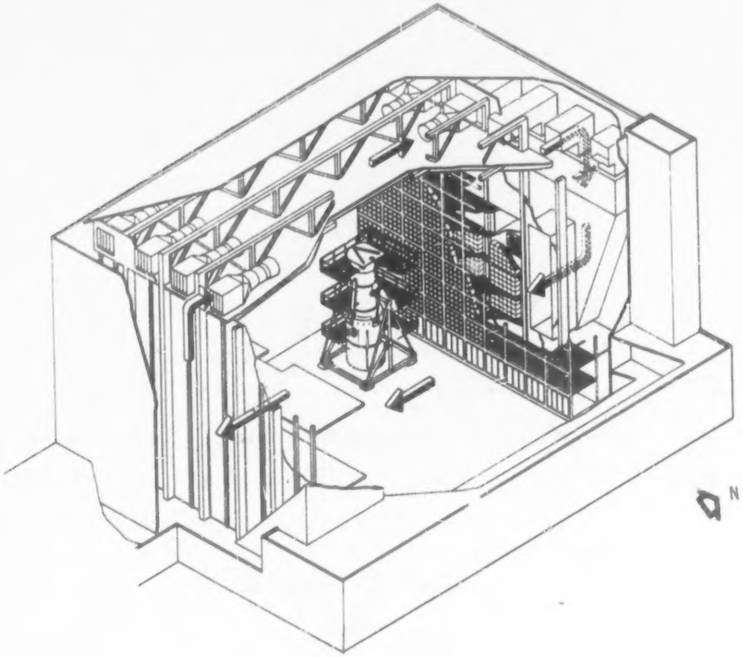

FIGURE 3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

SUMMARY

JET PROPULSION LABORATORY

Office of Space Science and Applications:	Amount	Page No.
Construction of Engineering Support Building	9,800,000	CF 5-1
Modification of Uninterruptible Power System in Space Flight Operations Facility	2,600,000	CF 5-8
Total	12,400,000	

JET PROPULSION LABORATORY
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF ENGINEERING SUPPORT BUILDING

LOCATION PLAN

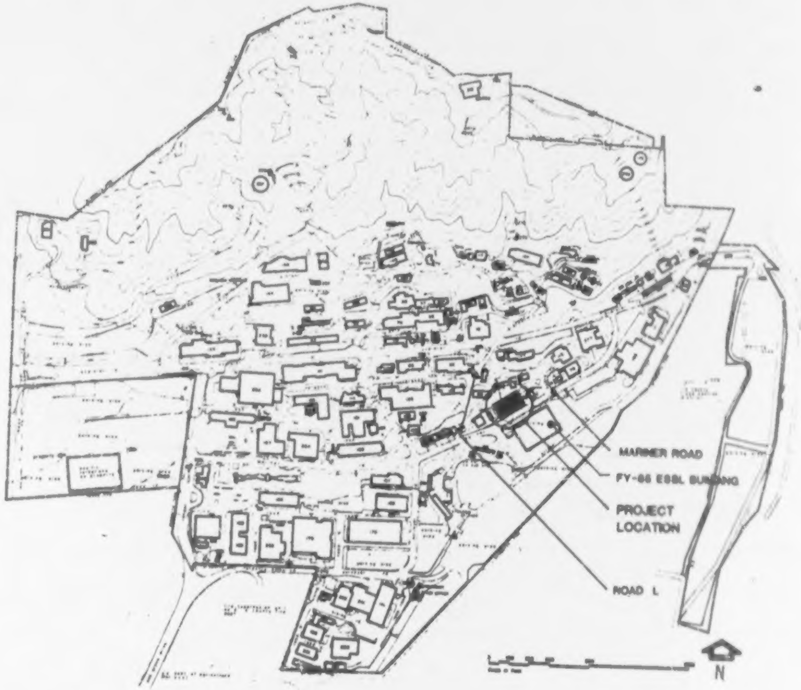
MARINER ROAD
FY-86 ESSL BUILDING
PROJECT LOCATION
ROAD L
N

FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE: Construction of Engineering Support Building

INSTALLATION: Jet Propulsion Laboratory

FY 1987 CoF Estimate: $9,800,000

LOCATION OF PROJECT: La Canada-Flintridge, Los Angeles County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Space Science and Applications

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding......................	588,000	---	588,000
Capitalized investment....................	N/A	---	---
Total..................................	588,000	---	588,000

SUMMARY PURPOSE AND SCOPE:

The project provides for the construction of a multi-story, 75,000-square foot engineering support building at the Jet Propulsion Laboratory. The proposed building will contain 40,600 square feet of administrative and engineering space, 17,400 square feet of technical laboratory space and a 17,000-square foot cafeteria with indoor and outdoor seating for 550 people. This building will provide space to house scientists, engineers and their staff who are presently located in expensive off-site leased space, on-site trailers and obsolete sub-standard buildings.

PROJECT JUSTIFICATION:

The Engineering Support Building (ESB) represents a key element of construction that will permit the return of the JPL staff from commercial leased space in Pasadena to the JPL site. This will result in significant improvements in operating efficiency and the elimination of costly leases which are presently required to house JPL personnel off-site. This facility will also permit elimination of seventeen 20-year old office trailers, and the demolition of three substandard structures on-site. This will further improve efficiency and reduce facility maintenance and operating costs.

In the latter half of 1986, off-site leased space will be reduced to approximately 83,000 square feet, serving a population of about 205. Construction of the ESB will permit the return of 180 of these people and the disposal of 60,000 square feet of the leased space in Pasadena. The remaining 25 people and 33,000 square feet of leased space will be maintained for the printing plant and records storage. Construction of the ESB will also permit the demolition of 15,100 square feet of obsolete, substandard space in Buildings 57, 80 and 106. These buildings are expensive to maintain and operate, are energy inefficient, and functionally obsolete. Rehabilitation would be uneconomical. This facility will also permit disposal of 17 trailers totaling 7,600 square feet. Maintenance and operating cost of these 20-year old trailers continues to increase rapidly each year.

The cafeteria facilities at JPL are currently housed in Buildings 167 and 190, and are designed to serve 2,400 meals per day during a 11:15 a.m to 1:30 p.m. lunch period. Both facilities are now serving in excess of 3,000 meals per day. Upon completion of on-going contruction, which will bring personnel on-site from leased space, the population will increase by 14 percent. This will place an even greater load on already overloaded food processing and service facilities. It is essential that this cafeteria be provided to accommodate the on-site population growth.

This project will provide significant savings by moving out of leased space, and eliminating substandard buildings and trailers. Intangible benefits will accrue by providing a more efficient operating environment for personnel resulting in increased productivity. This project will have a simple payback of less than 8 years.

IMPACT OF DELAY:

Delay in implementing this project will force the continued use of inefficient facilities and separate locations and adversely impact the JPL mission. There would be a need to continue to lease and occupy facilities that are distant from the main JPL site at costs exceeding a million dollars per year over the terms of the leases. Without this facility JPL will also have to continue to utilize substandard buildings and trailers which are costly to maintain and operate.

PROJECT DESCRIPTION:

The multi-story 75,000-square foot Engineering Support Building will be constructed of a lightweight steel frame with concrete floors on steel decking. The building is to be enclosed with insulated precast concrete panels and tinted heat absorbing glass. The first floor will house a cafeteria of approximately 17,000 square feet, which includes a kitchen, food storage, and preparation, serving and dining areas. An outside eating area will also be included. All other floors will house office and laboratory areas, with the necessary air-conditioning, utilities, and fire protection systems.

PROJECT COST ESTIMATE:

This cost estimate is based on two preliminary engineering reports.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	9,800,000
Sitework	LS	---	---	663,000
Architectural/structural	SF	75,000	69.60	5,220,000
Mechanical	SF	75,000	38.76	2,907,000
Electrical	SF	75,000	13.47	1,010,000
Equipment	---	---	---	---
Total				9,800,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - Project Rendering

OTHER EQUIPMENT SUMMARY:

Approximately $430,000 of R&D funded open office partitions, and security equipment will be required.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

No future funding is required to complete this facility.

JET PROPULSION LABORATORY
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF ENGINEERING SUPPORT BUILDING

SITE PLAN

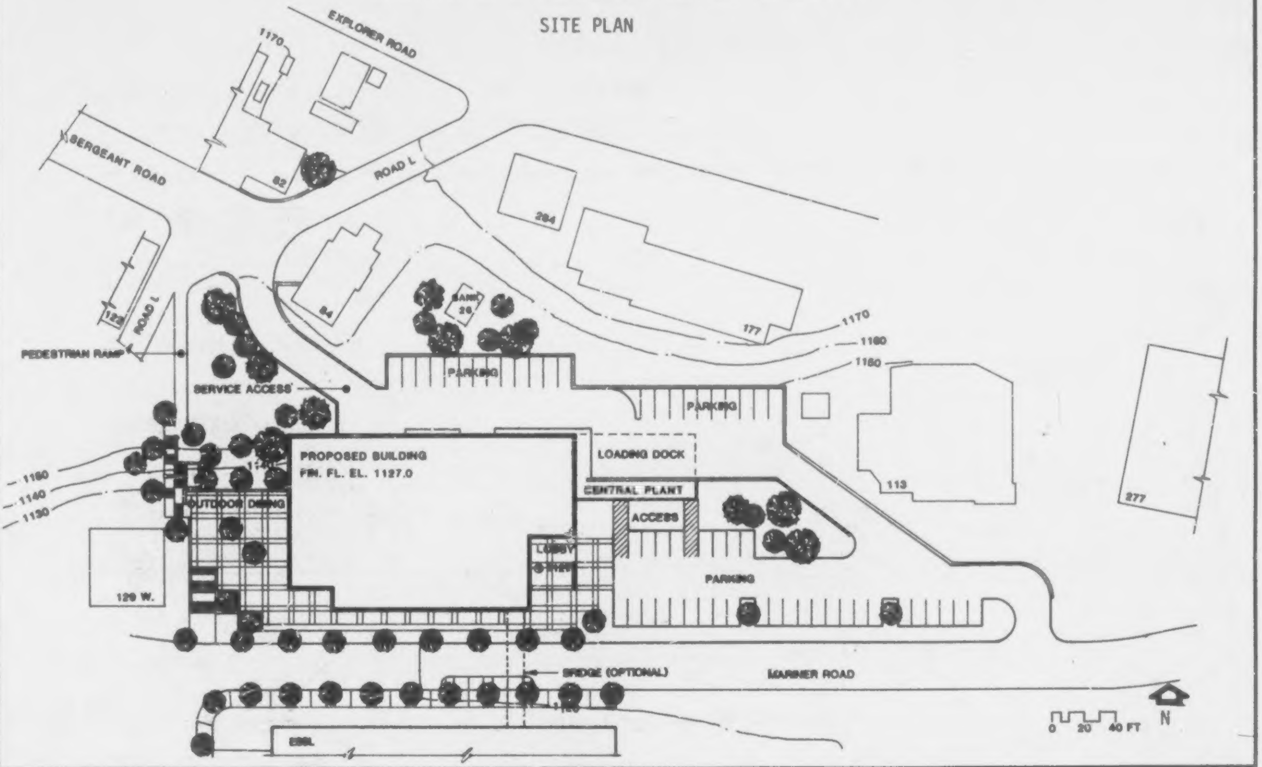
EXPLORER ROAD
1170
SERGEANT ROAD
ROAD L
82
264
84
BANK 26
177
1170
1160
1150
122
ROAD L
PEDESTRIAN RAMP
SERVICE ACCESS
PARKING
PARKING
PROPOSED BUILDING
FIN. FL. EL. 1127.0
LOADING DOCK
CENTRAL PLANT
ACCESS
LOBBY
@ 1127
113
277
1150
1140
1130
OUTDOOR DINING
129 W.
PARKING
BRIDGE (OPTIONAL)
MARINER ROAD
1120
ESSL
0 20 40 FT
N

FIGURE 2

JET PROPULSION LABORATORY
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF ENGINEERING SUPPORT BUILDING

PROJECT RENDERING

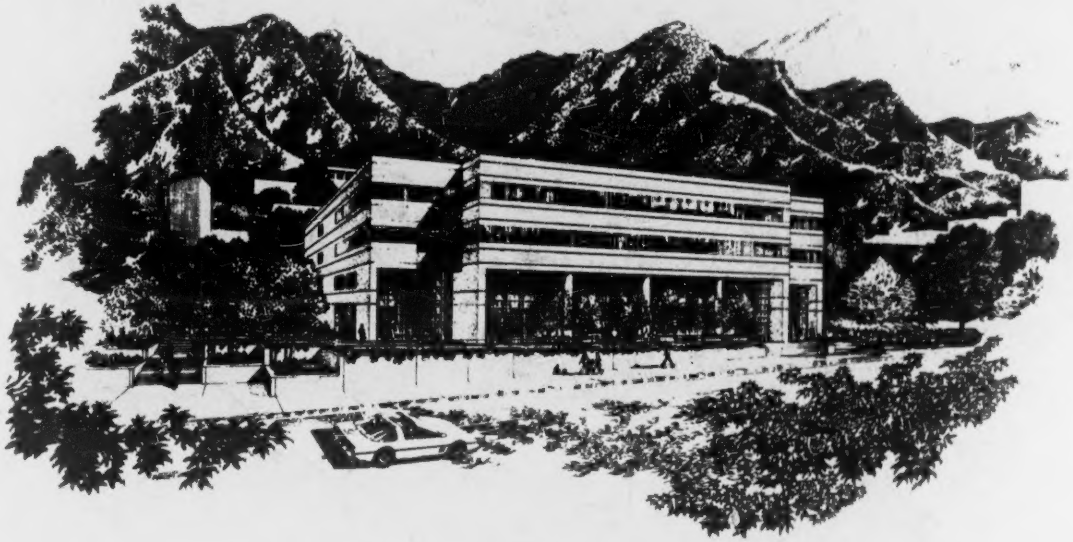

FIGURE 3

JET PROPULSION LABORATORY
FISCAL YEAR 1987 ESTIMATES
MODIFICATION OF UNINTERRUPTIBLE POWER SYSTEM IN SPACE FLIGHT OPERATIONS FACILITY

LOCATION PLAN

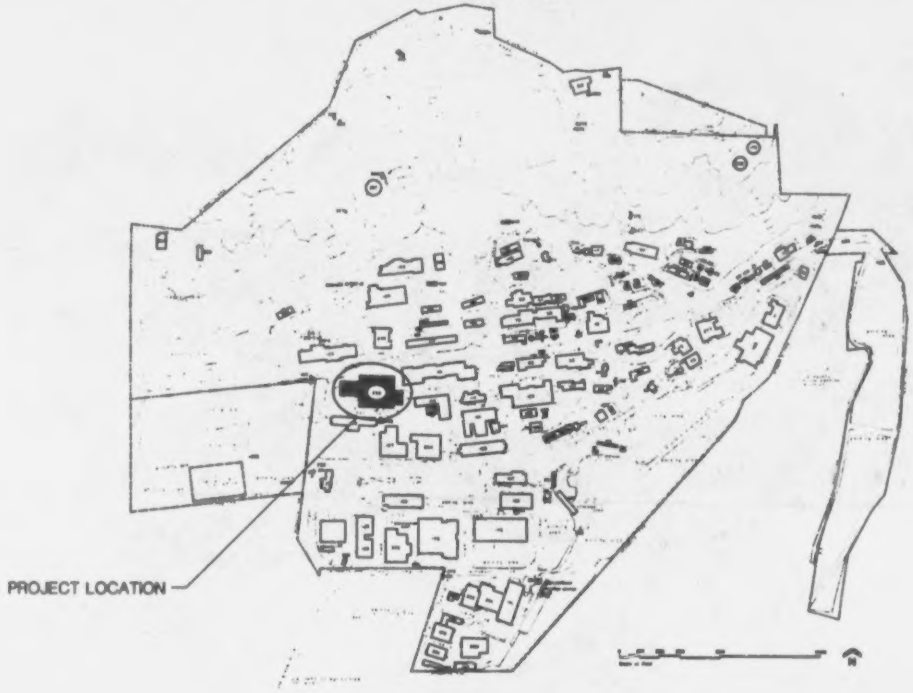

FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE:	Modification of Uninterruptible Power System in Space Flight Operations Facility
INSTALLATION:	Jet Propulsion Laboratory
FY 1987 CoF Estimate:	$2,600,000

LOCATION OF PROJECT: La Canada-Flintridge, Los Angeles County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Space Science and Applications

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding......................	204,000	---	204,000
Capitalized investment....................	N/A	13,120,568	13,120,568
Total..................................	204,000	13,120,568	13,324,568

SUMMARY PURPOSE AND SCOPE:

This project provides for the replacement of the Uninterruptible Power System (UPS) and upgrade of the secondary power distribution system in the Space Flight Operations Facility (SFOF), Building 230. The UPS supports all the critical computer equipment in the facility and is essential for a transient free and continuous source of electrical power. The existing UPS is 21 years old and is no longer manufactured. Spare parts are no longer available. A major failure of this UPS would disrupt the functioning of critical computer and communications equipment required for the operation and control of all planetary exploration spacecraft. This project will also correct low voltage conditions in the secondary power distribution system serving the computing equipment.

PROJECT JUSTIFICATION:

The Space Flight Operations Facility (SFOF) is the central facility at JPL for all data processing systems which track, control, and analyze data from spacecraft. These systems operate 24 hours a day, 365 days a year. The computers which process this data have electrical power tolerances which cannot be met by the commercial power distribution system and are consequently dependent on the UPS to provide a transient free and continous source of electrical power. A failure of the UPS system can cause a catastrophic failure of the computer systems which would severely impact planetary exploration missions such as Galileo and the Venus Radar Mapper (VRM).

The present UPS was one of three manufactured by the same vendor in the mid 1960's, and is the only surviving system of its type in operation. The manufacturer ceased production of this type of system 10 years ago and went out of the UPS business in the late 1970's. This has meant that the source of spare parts, service and technical support has almost totally disappeared. The ages of all of the major components of the system are greater than their normal life expectancy and some of the major components have now operated twice their expected life. The annual maintenance on the system requires it be shut down and the critical loads have to rely on commercial power during these periods. This year the system was down for 5 weeks for the annual maintenance compared to 2 weeks in 1982. Also, in 1982, no major parts required replacement compared to the necessity of replacing 14 major components in 1984. These spare parts had to be cannibalized from existing non-operative systems or made to order.

Voltage as low as 190 volts has been experienced in the 208 volt distribution system due to increasing computer loads. Such low voltage causes computers and their peripheral equipment to either go out of calibration, shut down, or perform erroneously. Data then becomes invalid, leading to serious problems with information transmission and receiving. This project will modify the electrical distribution system to eliminate the low voltage by installing a dedicated power distribution network for all computer systems.

IMPACT OF DELAY:

This project replaces the existing UPS prior to the Galileo Mission's encounter with Jupiter in 1988 and 1989 and the VRM Venus encounter in 1988. A delay of the project could jeopardize these missions, as well as numerous other planned missions which require SFOF support. The FY 1987 time-frame provides an excellent opportunity to shut down the UPS between critical missions. The next available construction opportunity would be in 1992. If the 1987 opportunity is missed, the existing failure-prone system may have to operate for another 5 years, which would greatly increase the probability of failure.

PROJECT DESCRIPTION:

The replacement UPS will be comprised of three 500KW modules, one of which will be redundant, providing a total system rating of 1,000 KW. The new system will include solid state controls, system and control redundancy, and forward and reverse bypass transfer. It will provide 15-minute battery backup, individual module isolation, provisions for periodic testing with load banks, and local and remote alarms. The system will be energy efficient and designed for efficient maintenance. It will also have a 25 percent growth and safety factor. The replacement of the existing UPS equipment will be accomplished within the same area by a phased equipment replacement process.

In addition to the UPS replacement, the building's electrical distribution system will be modified to provide additional capacity necessary to support current and anticipated programmatic growth and increased numbers of computers. This will be accomplished by changing the secondary distribution system from 208 to 480 VAC. The voltage regulators supplying regulated power to the computer systems will be replaced with new state-of-the-art units.

PROJECT COST ESTIMATE:

This cost estimate is based on two preliminary engineering reports.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	2,600,000
Sitework	LS	---	---	---
Architectural/structural	LS	---	---	95,000
Mechanical	LS	---	---	225,000
Electrical	LS	---	---	2,280,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)				---
Total				2,600,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan

OTHER EQUIPMENT SUMMARY:

No other equipment is required to complete this project.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

No future CoF funding will be required to complete this project.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

SUMMARY

AMES RESEARCH CENTER

Office of Aeronautics and Space Technology:	Amount	Page No.
Construction of Human Performance Research Laboratory...........................	9,400,000	CF 6-1

AMES RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF HUMAN PERFORMANCE RESEARCH LABORATORY

LOCATION PLAN

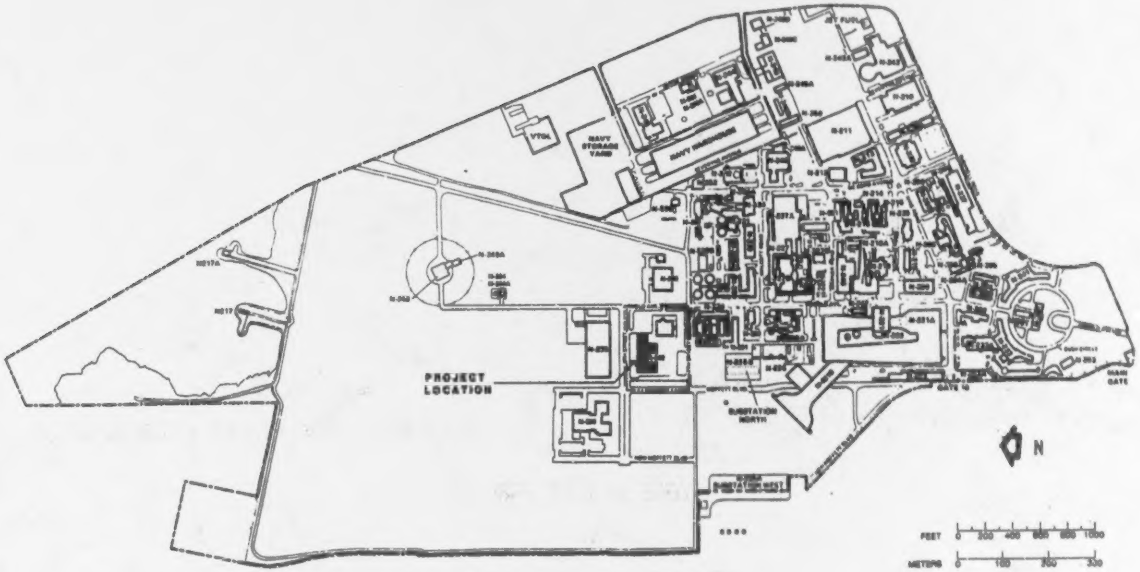
JET FUEL
N-211
N-210
VTOL
NAVY STORAGE YARD
NAVY WAREHOUSE
N217A
N217
PROJECT LOCATION
SUBSTATION NORTH
GATE 18
MAIN GATE
N
FEET 0 200 400 600 800 1000
METERS 0 100 200 300

FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE: Construction of Human Performance Research Laboratory

INSTALLATION: Ames Research Center

FY 1987 CoF Estimate: $9,400,000

LOCATION OF PROJECT: Moffett Field, Santa Clara County, California

COGNIZANT HEADQUARTERS OFFICES: Office of Aeronautics and Space Technology

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding......................	1,000,000	---	1,000,000
Capitalized investment....................	N/A	---	---
Total..................................	1,000,000	---	1,000,000

SUMMARY PURPOSE AND SCOPE:

The Human Performance Research Laboratory will provide otherwise unavailable laboratory and high bay space required to support NASA's commitment to meet the human factors research needs of a permanent manned presence in space. The 68,500-square foot facility will also provide the space into which the existing disciplinary human factors labs and support areas, already limited by the over-crowded conditions of buildings N239/239A and five trailers, will be relocated. This project will ensure that human resources factors are used to full advantage during future manned space missions and that levels of safety in manned space flight are enhanced through reductions in the incidence and severity of human error.

PROJECT JUSTIFICATION:

This laboratory will house the research activities related to human factors issues associated with long duration manned space flights. To assure the success of missions such as the Space Station, human performance and productivity must be examined and guidelines developed for the engineering and architectural design of the space habitat. Ames Research Center is assigned human factors research responsibility for both the man-in-space and the aeronautical environment. Space and aeronautical human factor problems are virtually identical. Therefore, better understanding of perception and cognition, performance measurement, and man-machine interaction increases human effectiveness and reduces errors in both space and aeronautical environments. This project will provide the facilities to conduct new studies to support a Space Station, and to accommodate continuing studies for man-in-space activities.

The Ames space human factors research plan includes crew interfaces with individual work stations, performance and workload studies, operations and design impact on productivity, and extravehicular activities research and technology. Task and mission studies conducted in flexible Space Station mock-ups will provide the greatest productivity, the least human error in Space Station operations, validate crew-habitat concepts, and minimize the risk associated with Space Station design decisions. This requires basic disciplinary laboratories and flexible station mock-ups. The close proximity of the labs and mock-ups will allow the investigators to develop mock-up studies and experiments with the aid of inexpensive local area network computer technology. The proposed laboratory will be used by approximately 185 people. About 160 of these people are currently at the Center in dispersed and very crowded conditions, many in trailers or other substandard space.

IMPACT OF DELAY:

Space Station architecture and task assignments research cannot be accomplished without a facility for mock-ups, laboratory research, and simulation. Failure to accomplish this research can jeopardize the full success and productivity of the Space Station. The proposed launch date dictates the earliest possible construction to allow maximum development time prior to final design of the Space Station.

PROJECT DESCRIPTION:

This project provides a new 68,500-square foot two-story laboratory and high bay steel frame and concrete building adjoined to existing building N-257 by a covered breezeway. The high bay area comprising approximately 12,000 square feet will house the Space Station mock-ups that will be used for human performance evaluations. Additionally, the high bay will house a staging and assembly area, mock-up support areas, and an evaluation development laboratory. Support areas adjacent to the high bay include a space human factors lab, aeronautical human factors lab, perception and cognition lab, and a central computing laboratory. The second floor will house the human-machine interactions lab, performance assessment lab, additional computer laboratories, along with office and technical support areas. Individual HVAC systems will be provided for the central computer areas. Laboratory, office, and technical support areas will be provided with a separate HVAC system. The project will include site work, additional parking, paving, electrical, plumbing, and support utilities including diesel driven emergency power, conditioned power for laboratory and computer equipment, two separate grounding systems, fire detection and dry pipe suppression system, and a local communications network for remote computer terminal links to the main frame central computers.

PROJECT COST ESTIMATE:

The current cost estimate is based on a July, 1985 Preliminary Engineering Report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	9,400,000
Site preparation	LS	---	---	1,100,000
Architectural/structural	SF	68,500	68.61	4,700,000
Mechanical	SF	68,500	36.50	2,500,000
Electrical	SF	68,500	16.06	1,100,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				9,400,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Evaluation and Site Plan
Figure 3 - Cut-Away Schematic

OTHER EQUIPMENT SUMMARY:

Computer and laboratory equipment will be relocated from other buildings. Elements of the Space Station mock-ups will be relocated from other sites on the center and assembled in the high bay area.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

No future Cof funding is required to complete this project.

AMES RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF HUMAN PERFORMANCE RESEARCH LABORATORY

SITE PLAN

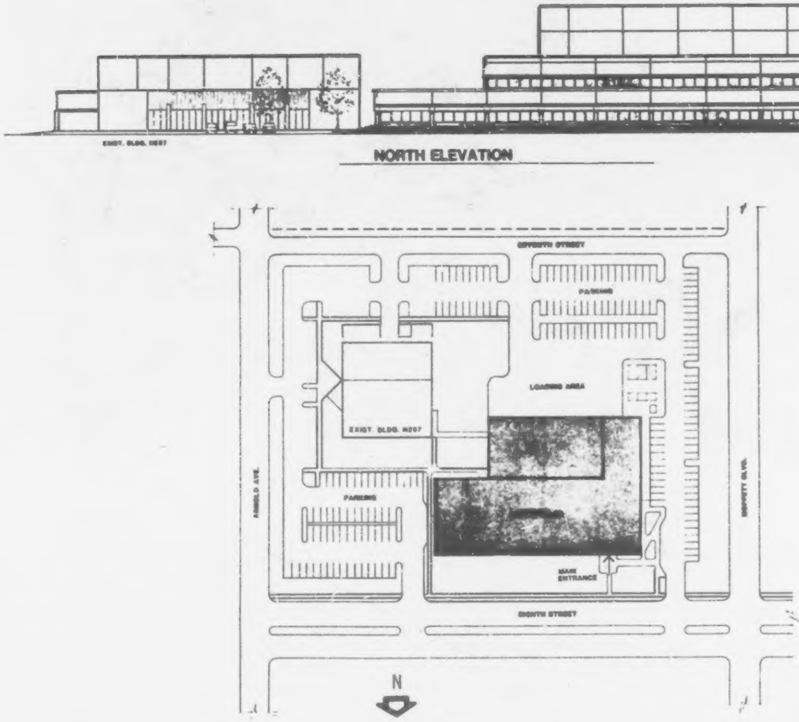
EXIST. BLDG. N257
NORTH ELEVATION
SEVENTH STREET
PARKING
LOADING AREA
EXIST. BLDG. N257
ARNOLD AVE.
PARKING
MAIN ENTRANCE
EIGHTH STREET
N

FIGURE 2

AMES RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF HUMAN PERFORMANCE RESEARCH LABORATORY

CUT-AWAY SCHEMATIC

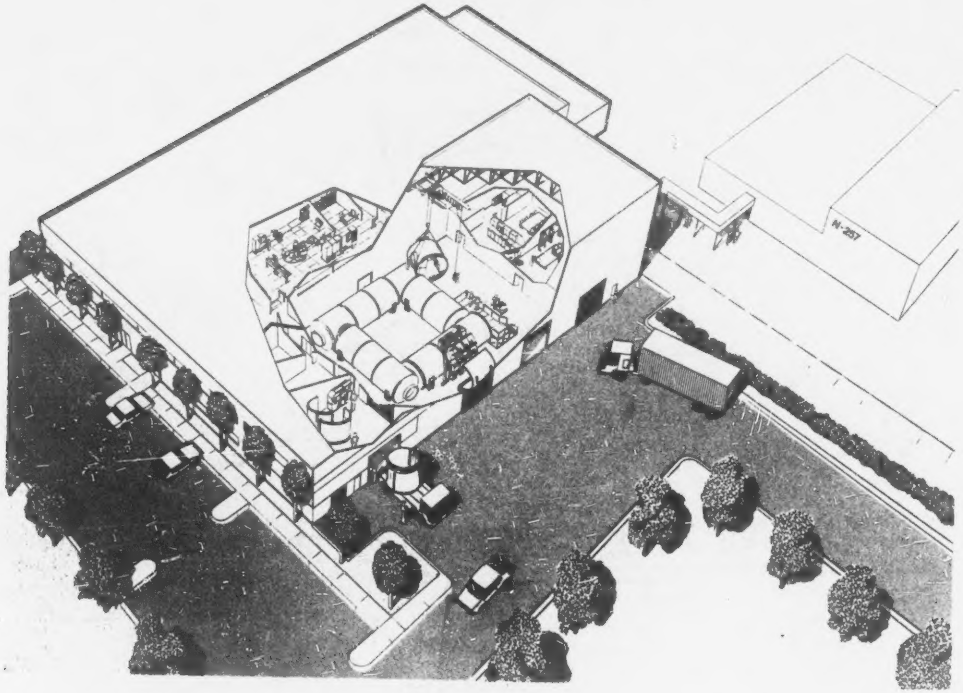

FIGURE 3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

SUMMARY

DRYDEN FLIGHT RESEARCH FACILITY

Office of Aeronautics and Space Technology:	Amount	Page No.
Construction of Integrated Test Facility......................................	17,500,000	CF 7-1

DRYDEN FLIGHT RESEARCH FACILITY
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF INTEGRATED TEST FACILITY

LOCATION PLAN

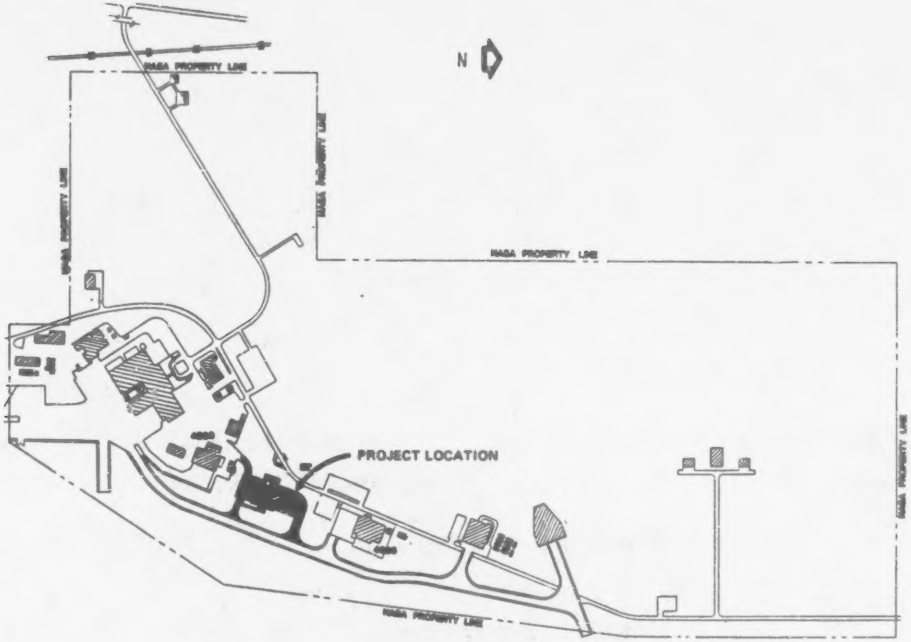
N
NASA PROPERTY LINE
NASA PROPERTY LINE
NASA PROPERTY LINE
NASA PROPERTY LINE
NASA PROPERTY LINE
NASA PROPERTY LINE
PROJECT LOCATION

FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE: Construction of Integrated Test Facility

INSTALLATION: Dryden Flight Research Facility

FY 1987 CoF Estimate: $17,500,000

LOCATION OF PROJECT: Edwards AFB, Kern County, California

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding......................	1,200,000	---	1,200,000
Capitalized investment....................	N/A	---	---
Total..................................	1,200,000	---	1,200,000

SUMMARY PURPOSE AND SCOPE:

The Integrated Test Facility (ITF) is essential for NASA to maintain its pre-eminence in aeronautical research. The last decade has seen an exponential growth of electronic digital control for aircraft systems. Vehicles are being designed with integrated systems for flight control, fire control, flutter suppression, flight management, etc. The ITF will accommodate checkout of each component and the interaction between components during closed loop operations of the overall integrated system. An adequate ground testing facility for these highly integrated and interactive systems does not currently exist at the Dryden Flight

Research Facility. This project will provide aircraft test areas and computer laboratory space required for the complex testing of these highly interactive systems in both the aircraft of today, and those of tomorrow.

PROJECT JUSTIFICATION:

NASA requires an Integrated Test Facility (ITF) for developmental testing of systems driven aircraft (i.e. aircraft dominated by digital flight control systems) prior to and during the flight test program. Based on the number of programs involving these types of aircraft, the increased degree of interaction between systems, and the dominance of the systems over aircraft flight behavior, it will be highly inefficient at best to continue to support these flight programs with the current facilities which are separated in approximately eight different locations and are not suitable for support of total systems integration testing.

Systems driven aircraft are characterized by large numbers of interacting systems, some involving crucial flight safety functions, and by the flight control functions having dominance over the aircraft dynamics. To develop, qualify or troubleshoot systems of this type, three conditions must be met: 1) capability for progressive testing complexity; 2) the test aircraft must eventually be tied into the simulation and ground based systems; and 3) the ground test equipment, gear and simulation equipment must be in close proximity to the systems undergoing test.

Existing facilities are only able to support a limited number of system driven aircraft. Even this limited capability assumes that test equipment requirements are similar to those of previous programs. This has the effect of forcing each new program to purchase specialized test equipment to meet the needs of new requirements. Another deficiency is marginal or no signal communications links between aircraft, simulation laboratories, and the remote testing areas. No capability exists for operating an engine while exercising the flight control loops through the aerodynamic simulations. This is critical for aircraft with integrated flight propulsion control systems. No capability now exists to check out special sensor devices such as laser gyros and infrared sensors. There is no Electromagnetic Interference (EMI) shielding from background radiation during calibration tests, nor to prevent unauthorized satellite capture of secure radiation patterns. Also, ground vibration, moment of inertia, and aeroservoelastic ground testing are limited by a lack of environmentally controlled test areas and hangar space with adequate height and strength to support dynamic testing of structural components, as well as the entire aircraft.

New aircraft targeted for introduction in the 1990's will all be systems driven aircraft. Along with the new aircraft, for example the X-29 and the AFTI-16, rapid advancement in avionics technologies are foreseeable and expected. These advancements will lead to requirements that cannot be supported by the present facilities, such as, testing integrated aircraft systems and assessing system interactions, and interrogating avionics and software intensive systems.

IMPACT OF DELAY:

NASA currently has no facility capable of integrated system testing. Existing facilities can provide complex tests on simple systems, but not complex tests on complex systems. Without an integrated testing capability, more risks will be incurred in flight; a "mini - ITF" must be developed for each specific program at higher costs; all tests must be conducted in piecemeal fashion; development and qualification time will be extended; and higher risk flight testing will be required to qualify systems.

PROJECT DESCRIPTION:

This project provides for construction of a 112,000-square foot Integrated Test Facility composed of six (6) aircraft hanger-type test bays totaling 53,000 square feet and an ajoining 59,000-square foot two-story masonry structure housing computer, laboratory, office, and technical support areas. Each of the six test bays will be large enough to house conventional and/or experimental type fighter or research aircraft, or three bays can be opened to accommodate large aircraft. Each test bay will be provided with: data bus and discrete interface control and logic points, power (115VAC, 208VAC, 28VDC, 270VDC at 400 Hz and 60Hz), cooling air for aircraft systems, hydraulic support systems, ambient heating systems, industrial waste collection systems, fire suppression, shop air, overhead cranes, and shielding. At least one bay will be provided with EMI shielding to protect sensitive electronic systems from externally generated electromagenetic radiation. The laboratories and shop areas, will be provided with power, HVAC, plumbing, fire detection and suppression, a central 4,000 psig hydraulic system manifolded through-out the complex, compressed air, lighting, and emergency power. Also to be provided is a building grounding system including separate aircraft test system grounds, lightning protection, paving, taxiways, parking, and landscaping.

PROJECT COST ESTIMATE:

The current cost estimate is based on a June 1985 Preliminary Engineering Report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	17,500,000
Civil	LS	---	---	2,100,000
Architectural/structural	SF	112,000	86.60	9,700,000
Mechanical	SF	112,000	35.71	4,000,000
Electrical	SF	112,000	15.18	1,700,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				17,500,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Interior View

OTHER EQUIPMENT SUMMARY:

Computer equipment and aircraft test equipment is presently at Dryden and will be supplemented with equipment purchased with $2,900,000 of FY 1988 and 1989 R&D funds.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

No additional CoF funding is anticipated to complete this project.

DRYDEN FLIGHT RESEARCH FACILITY
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF INTEGRATED TEST FACILITY

INTERIOR VIEW

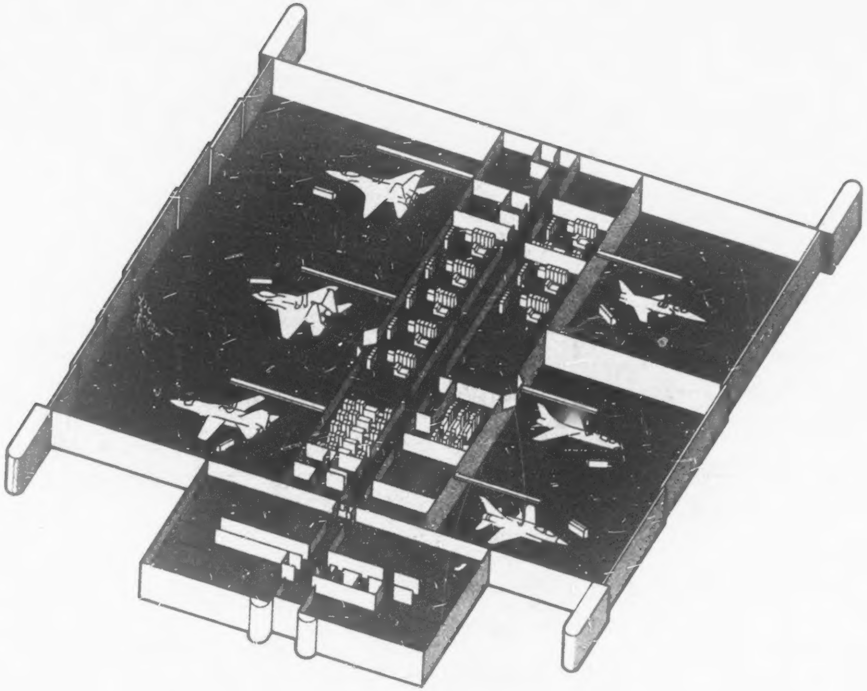

FIGURE 2

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

SUMMARY

LANGLEY RESEARCH CENTER

Office of Aeronautics and Space Technology:	Amount	Page No.
Modifications to 8-Foot High Temperature Tunnel	9,700,000	CF 8-1
Construction of Addition for Non-Destructive Evaluation Research Laboratory	2,000,000	CF 8-8
	11,700,000	

LANGLEY RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
MODIFICATIONS TO THE 8-FOOT HIGH TEMPERATURE TUNNEL

LOCATION PLAN

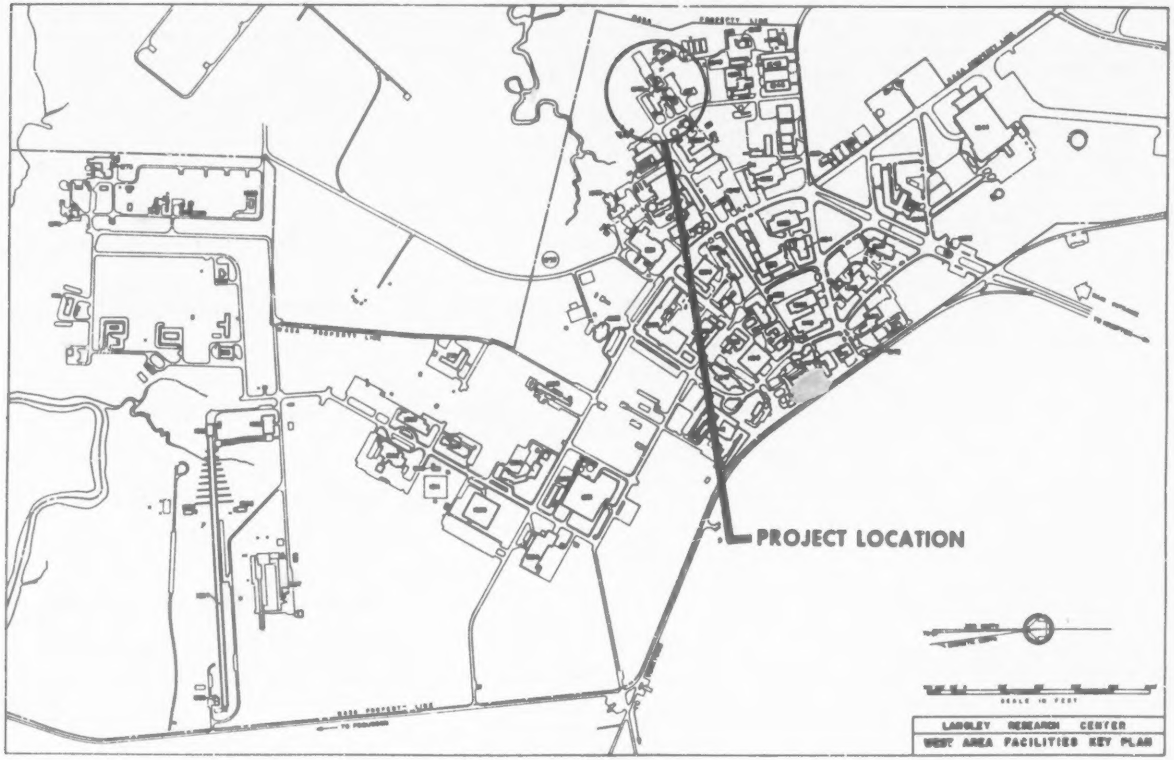
PROJECT LOCATION
NASA PROPERTY LINE
LANGLEY RESEARCH CENTER
WEST AREA FACILITIES KEY PLAN
SCALE IN FEET

FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE: Modifications to 8-Foot High Temperature Tunnel

INSTALLATION: Langley Research Center

FY 1987 CoF Estimate: $9,700,000

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding......................	1,839,000	13,800,000	15,639,000
Capitalized investment....................	N/A	14,537,666	14,537,666
Total..................................	1,839,000	28,337,666	30,176,666

SUMMARY PURPOSE AND SCOPE:

This project will complete necessary modifications to the 8-foot High Temperature Tunnel (HTT) to advance supersonic and hypersonic research capability. The project, when completed, will provide a unique national research facility capability for hypersonic propulsion and aerothermostructural research for transatmospheric vehicles and missiles at altitudes from 50,000 feet to 130,000 feet with nominal Mach numbers between 4.0 and 7.0. This follow-on increment of construction involves: (1) replacement of high pressure methane compressors, (2) installation of high-speed video cameras, (3) the addition of a flow mixer and two new interchangeable nozzles to expand test simulation capability from the existing nominal Mach 7.0 down to Mach 4.0, and (4) installation of additional controls and instrumentation.

PROJECT JUSTIFICATION:

Capability in this country for testing air breathing propulsion and missile systems over the nominal Mach number range of 4.0 to 7.0 is severely limited. Existing facilities, such as the Arnold Engineering Development Center (AEDC) Aero Propulsion Test Unit (APTU) and Aero Propulsion System Test Facility (ASTF) can only accommodate full-scale ramjets and missiles up to about Mach 4. Other test facilities that can simulate flight Mach numbers up to 7, are too small and can accommodate only incomplete subscale engines or components. The 8-Foot High Temperature Tunnel (HTT) (Figure 2), is the only existing facility that can be modified to provide the required full scale testing capability through the range of Mach 4-7. A comparison of the proposed operational envelope of the 8-Foot HTT compared to that of the AEDC's (APTU) and (ASTF) is shown in Figure 3.

LaRC has, for many years, been developing a technology base for hydrogen and hydrocarbon scramjets at high Mach number conditions and has conducted many evaluations on incomplete subscale engines. The modifications included in this project were originally a part of the FY 1985 CoF project authorized at $13.8M. The FY 1985 project's scope and budget were based on a preliminary engineering report that outlined the modifications necessary to provide the stated requirements. During final design the tunnel computer simulations and pilot tunnel testing were finalized. The results clearly surfaced that the technical complexity of satisfying essential requirements was found to be seriously underestimated. Testing and simulations clearly indicated that by expanding original criteria and requirements, a much more useful performance envelope for the tunnel could be achieved. Similarly, the testing and simulations showed that the earlier requirements had been compromised. Detailed safety reviews, and third party performance reviews also resulted in necessary revisions of the original requirements; especially those concerning the LOX supply and distribution system and tunnel system controls. In summary significant cost increases were necessary and resulted from changes within three general categories: a) operational enhancement and criteria, b) safety analysis and third party review, and c) detailed design integration improvement.

After detailed review and study of the situation, NASA has determined that the enhanced design is significantly more beneficial for basic research. The original FY 1985 project at $13.8M upgrades the 20-year old facility to reestablish the tunnel baseline configuration at Mach 7.0 with new transpiration cooled components, and provides O_2 enrichment that will provide a new capability for propulsion testing. This FY 1987 project will complete the tunnel improvements by expanding the test capability down to the Mach 4 and 5 region. Full scale testing will now be possible at the critical transition region between that of a ramjet and scramjet. For the first time there will be a full scale propulsion test facility capable of testing throughout the entire range of ramjet/scramjet propulsion systems. Also full-scale tests will be possible to evaluate a complete flight-weight, flight scale air breathing engine system and to determine integrated engine component interactions, cooling performance, thermal structural performance, and engine-airframe interaction effects.

IMPACT OF DELAY:

Delay of this project would have a significant impact on providing a facility capable of providing the research environment necessary for NASA's basic research associated with scramjet propulsion systems. Also affected would be delays in proposed DOD missle development programs. Without these modifications the existing tunnel cannot provide the capability of testing at the MACH 4 and 5 conditions which is absolutely crucial for transition research between ramjet and scramjet-flight.

PROJECT DESCRIPTION:

Modifications include fabrication and installation of a new alternate mach number mixing chamber to condition the gas flow at the basic MACH 7 flow before expansion to lower Mach numbers when required. Two additional nozzles nominally rated at Mach 4.0 and 5.0, respectively, will be provided for attachment to the alternate mach number mixer to provide lower mach flows to the existing Mach test chamber flow. An existing 6000 psig air supply line will be extended, enhanced controls will be provided, 25-year old methane compressors will be replaced, and a new high quality high speed computer controlled video camera system will be installed in the tunnel to improve productivity by allowing for real time data validation and verification.

PROJECT COST ESTIMATE:

Project cost estimate are based on final design and 3rd party cost validations.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	9,700,000
Methane compressors	LS	---	---	632,000
High -speed TV system	LS	---	---	292,000
Alternate mach numbers	LS	---	---	7,222,000
Controls	LS	---	---	1,418,000
Checkout	LS	---	---	136,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				9,700,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - Comparison of Operational Envelope for LaRC's 8-Foot HTT and AEDC Propulsion Facilities (ASTF and APUT)

OTHER EQUIPMENT SUMMARY:

Approximately $1,850,000 of R & D funds will be required for Data Acquisition Systems.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

No future CoF funding is anticipated to be required to complete this project.

LANGLEY RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
MODIFICATIONS TO THE 8-FOOT HIGH TEMPERATURE TUNNEL

SITE PLAN

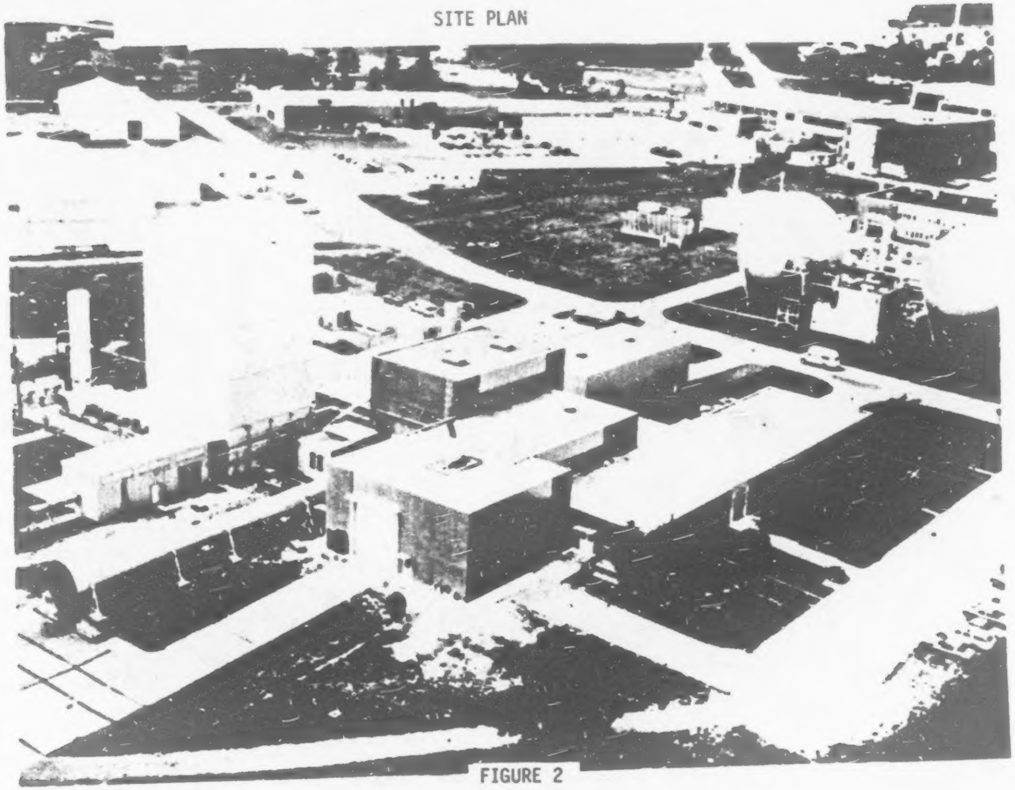

FIGURE 2

LANGLEY RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
MODIFICATIONS TO THE 8-FOOT HIGH TEMPERATURE TUNNEL

COMPARISON OF OPERATIONAL ENVELOPES FOR LaRC'S 8-FOOT
HTT AND AEDC PROPULSION FACILITIES (ASTF AND APTU)

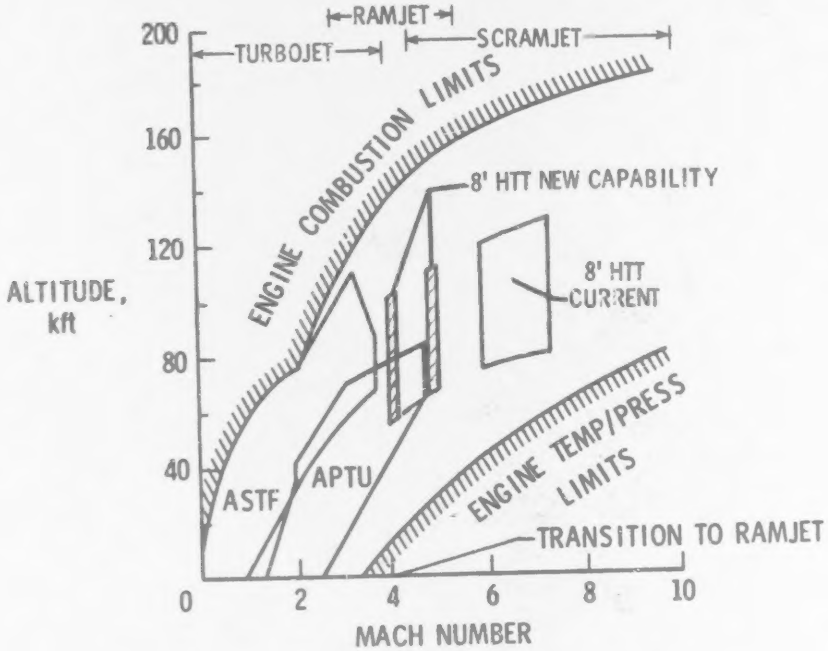

FIGURE 3

LANGLEY RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF ADDITION FOR NON-DESTRUCTIVE EVALUATION RESEARCH LABORATORY (1230)

LOCATION PLAN

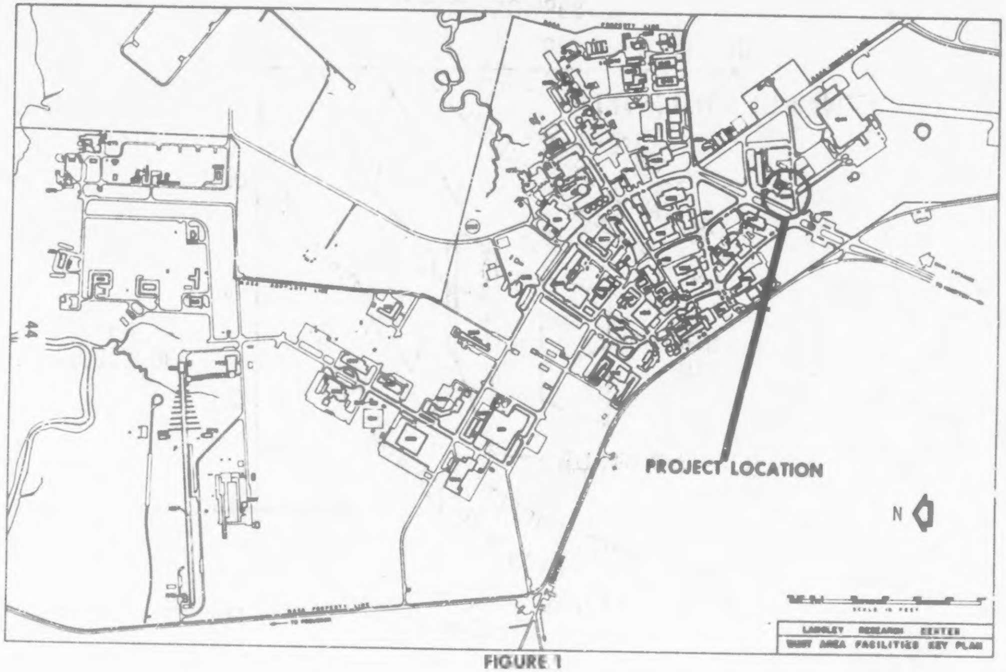
44
PROJECT LOCATION
N
SCALE IN FEET
LANGLEY RESEARCH CENTER
WEST AREA FACILITIES KEY PLAN

FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE:	Construction of Addition for Non-Destructive Evaluation Research Laboratory
INSTALLATION:	Langley Research Center
FY 1987 CoF Estimate:	$2,000,000

LOCATION OF PROJECT: Hampton, Virginia

COGNIZANT HEADQUARTERS OFFICE: Office of Aeronautics and Space Technology, Office of Chief Engineer

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding........................	192,560	---	192,560
Capitalized investment......................	N/A	3,499,532	3,499,532
Total....................................	192,560	3,499,532	3,692,092

SUMMARY PURPOSE AND SCOPE:

This project will provide a two-story addition to Building 230 to accommodate a Non-Destructive Evaluation (NDE) Laboratory capable of housing state-of-the-art instrumentation for research in quantitative materials characterization. Aerospace material selection is important for all major structures and other critical components such as solar power systems, optical systems, and thermal control surfaces. This facility will include a laboratory for remote strain and high-resolution sensing, and for development of an energy probe capable of remotely monitoring large space structures to study geometry, vibrational modes, local stress fields, velocity, and accelerations. It will also provide space for supportive NDE research for aircraft parts, materials evaluation, and recertification programs.

PROJECT JUSTIFICATION:

This facility will provide new capability for non-destructive evaluation (NDE) research programs which are focused on improving the interpretability of research data by advancing the state-of-the-art in instrumentation, physical measurement, and analysis. Examples of critical government, and industry programs requiring the advanced NDE technology that will be developed in this laboratory are those for filament-wound composites (FWC), solid rocket motors (SRM), control of flexible structures (COFS), mobile satellite (MAST), Space Shuttle thermal protection systems (TPS), Space Station, large antennas, advanced composite aircraft, and ground facilities recertification. Improvements in these programs require identification of failure paths and modes before they become critical. This is not possible with existing technology. Recent advances in quantifying the physics of the measurement process have produced many new promising concepts for NDE. However, these measurement advances must be transfered to specific applications. For example, such improvements would have application in the integration of composite materials into critical components of aerospace structures. Also, electronic type failures recently experienced with several satellites such as Westar VI and Solar MAX could possibly be prevented in the future if new NDE practices can be perfected.

This facility addition will include a space-structure sensors/instrumentation lab to develop advanced measurement technology practices. Research will focus on remote sensing of structural integrity through noncontacting strain readout and acoustic emission sensors. New X-ray tomography equipment will help build a better science base for X-ray tomography by increasing the understanding of the measurements being made and then reducing the data to a form which describes the physical properties of a structure. A new twin robotic scanner system will be used to demonstrate the application of new nonlinear and multiparameter ultrasonic techniques for complex aerospace structures. As aerospace structures become more complex no single NDE measurement will be able to certify the integrity of a structure. This laboratory will allow research into the characterization of structures by integration of fundamentally different, yet complimentary, techniques.

IMPACT OF DELAY:

A delay in the construction of this laboratory addition will cause unacceptable delays in the development of the NDE and quantitative physical characterization (QPC) programs for measurements required to insure the integrity of advanced space systems. Recent problems, both on the ground and in space, point to the fine threshold between success and failure when requirements push structures to the limits of design. A significant increase in R&D equipment and staff for both NDE and QPC is included in current plans. Without this laboratory, Langley will not be able to house new research equipment.

PROJECT DESCRIPTION:

The project will provide a 16,600-square foot two-story addition to Building 1230 to house state-of-the-art research equipment for materials evaluation. Included will be a 1,600-square foot high-bay research area.

In addition to the high-bay there will be laboratories for process control, remote strain sensing development, sensor instrumentation, acoustic emission, and electromagnetic interaction, and approximately 2,000 square feet of office and support space. Associated heating, ventilating, air-conditioning, and other related utilities will be provided as needed.

PROJECT COST ESTIMATE:

Project cost estimates are based on a July 1985 preliminary engineering report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	2,000,000
Architectural/Structural	SF	16,600	75.30	1,250,000
Mechanical	LS	---	---	505,000
Electrical	LS	---	---	245,000
Equipment	---	---	---	---
Fallout Shelter (not feasible)	---	---	---	---
Total				2,000,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Site Plan
Figure 3 - Concept Layout of Proposed Addition

OTHER EQUIPMENT SUMMARY:

R&D funds totalling approximately $1M are planned for research equipment.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

No future CoF funding is required to complete this project.

LANGLEY RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF ADDITION FOR NON-DESTRUCTIVE EVALUATION RESEARCH LABORATORY (1230)

SITE PLAN

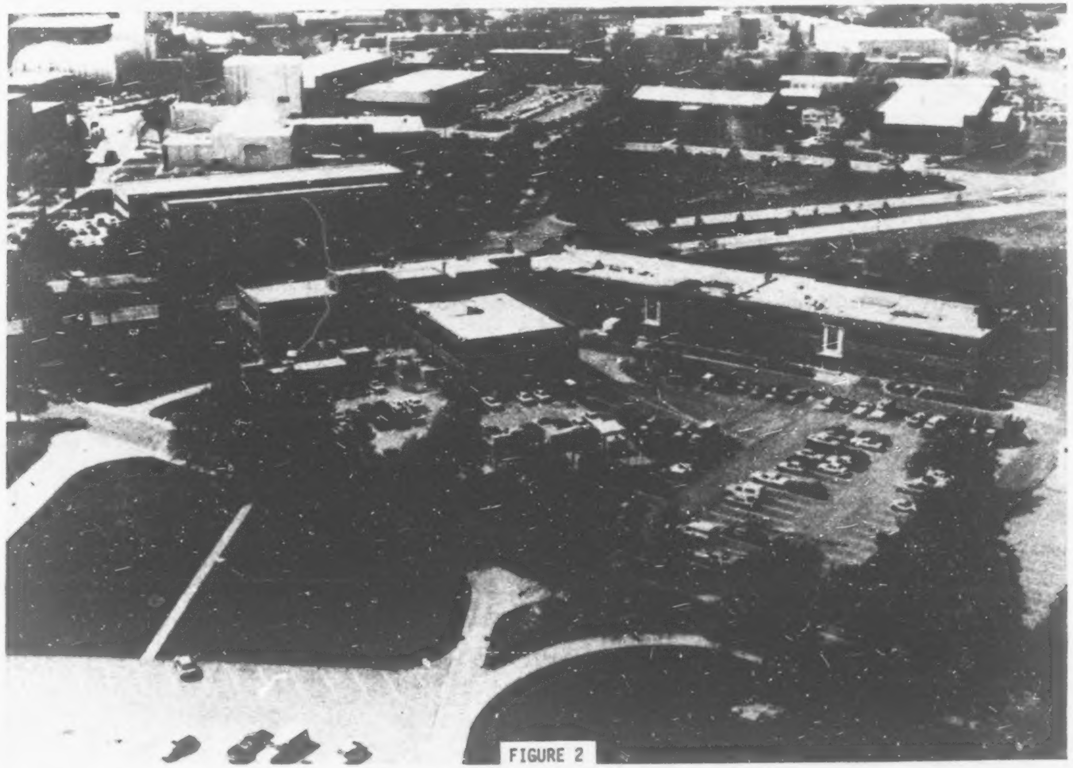
FIGURE 2

CF 8-13

LANGLEY RESEARCH CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF ADDITION FOR NON-DESTRUCTIVE EVALUATION RESEARCH LABORATORY (1230)

CONCEPT LAYOUT OF PROPOSED ADDITION

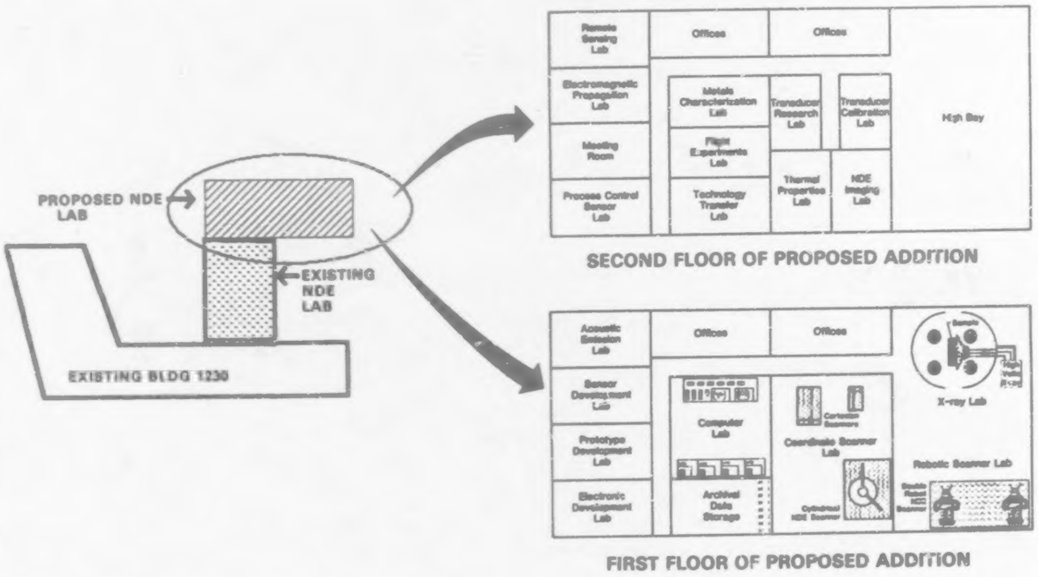
PROPOSED NDE LAB
EXISTING NDE LAB
EXISTING BLDG 1230
Remote Sensing Lab
Offices
Offices
Electromagnetic Propagation Lab
Metals Characterization Lab
Transducer Research Lab
Transducer Calibration Lab
High Bay
Meeting Room
Flight Experiments Lab
Process Control Sensor Lab
Technology Transfer Lab
Thermal Properties Lab
NDE Imaging Lab
SECOND FLOOR OF PROPOSED ADDITION
Acoustic Emission Lab
Offices
Offices
Sample
X-ray Lab
Sensor Development Lab
Computer Lab
Cartesian Scanners
Coordinate Scanner Lab
Prototype Development Lab
Robotic Scanner Lab
Electronic Development Lab
Archival Data Storage
Cylindrical NDE Scanner
Robot NDE Scanner
FIRST FLOOR OF PROPOSED ADDITION

FIGURE 3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

SUMMARY

VARIOUS LOCATIONS

Office of Space Tracking and Data Systems:	Amount	Page No.
Construction of the Second Tracking and Data Relay Satellite System Ground Terminal Facility in New Mexico	22,000,000	CF 9-1

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF THE SECOND TRACKING AND DATA RELAY SATELLITE SYSTEM
GROUND TERMINAL FACILITY, NEW MEXICO

LOCATION PLAN

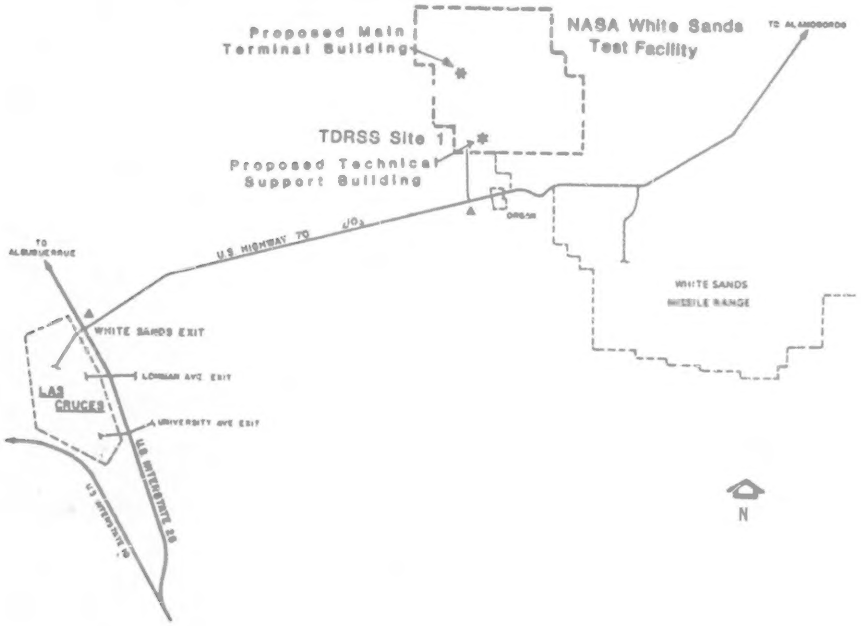
Proposed Main Terminal Building
NASA White Sands Test Facility
TO ALAMOGORDO
TDRSS Site 1
Proposed Technical Support Building
ORGAN
U.S. HIGHWAY 70 /(O)
TO ALBUQUERQUE
WHITE SANDS EXIT
LOHMAN AVE EXIT
LAS CRUCES
UNIVERSITY AVE EXIT
U.S. INTERSTATE 25
U.S. INTERSTATE 10
WHITE SANDS MISSILE RANGE
N

FIGURE 1

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE:	Construction of the Second Tracking and Data Relay Satellite System Ground Terminal Facility in New Mexico
INSTALLATION:	White Sands Test Facility, Las Cruces, New Mexico
FY 1987 CoF Estimate:	$22,000,000

LOCATION OF PROJECT: Las Cruces, Dona Ana County, New Mexico

COGNIZANT HEADQUARTERS OFFICE: Office Of Space Tracking and Data Systems

FY 1986 AND PRIOR YEARS FUNDING: The following prior years funding is related to this project:

	Planning and Design	Construction	Total
Specific CoF funding......................	320,000	---	320,000
Capitalized investment....................	N/A	---	---
Total....................................	320,000	---	320,000

SUMMARY PURPOSE AND SCOPE:

This project provides for construction of 118,000-square feet of additional Tracking and Data Relay Satellite System (TDRSS) Space Network ground segment facilities. This new ground terminal will be a backup to the present White Sands Ground Terminal, which is a single node in the control of the Nation's vital space programs. An 84,000-square foot terminal building and a 6,000-square foot power plant will be sited three miles north of the existing ground terminal at NASA's White Sands Test Facility in New Mexico. An associated 28,000-square foot technical support facility will be sited adjacent to the existing terminal.

PROJECT JUSTIFICATION

The present ground terminal for the TDRSS Space Network is the only ground tracking station able to function with TDRSS satellites for supporting the Nation's orbital spacecraft missions. As such, it is a single point of failure in the critical tracking, control, and data acquisition support to these missions. Such failures can include ground terminal hardware and software failures, operational errors, or major failures in the power distribution system, the emergency backup power system, or the air-conditioning systems for equipment and building cooling. Also, a catastrophic event, such as a fire within the ground terminal, could cause an extended ground terminal outage. Experience with the present ground terminal since it became operational in January 1984 has shown that its complexity makes it difficult to operate and maintain. Although significant improvements have been made, longer range plans include major system replacements that will require the present ground terminal to be off-line for extended periods. A backup to the present ground terminal is essential for minimizing the potential loss of critical space assets or data due to a TDRSS ground segment outage from any cause.

Following the 1986 phasedown of the ground based Spaceflight Tracking and Data Network (STDN), the TDRSS Space Network becomes the only lifeline of communications and tracking support for the Space Shuttle and other near-earth orbit spacecraft. This, coupled with the increased frequency of shuttle flights and other critical satellite support required from the Space Network including support for the Hubble Space Telescope, makes continuous TDRSS operational support vitally important. Because loss of communications could endanger astronauts or result in loss of critical mission data, a backup to the present ground terminal is essential to eliminate the present single point of failure in the TDRSS ground segment. It is also key to sustaining mission support during upgrading of the systems in the present ground terminal.

In addition to being a backup to the present terminal, the second ground terminal will provide the flexibility for supporting additional orbital spacecraft in the space station era through the use of more TDRSS satellites. Each satellite requires a dedicated ground antenna and related electronic system. Although the present ground terminal can communicate with all three TDRSS satellites in the initial Space Network configuration, the system provides for full operational use of only two of the three. The site selected for this second terminal will satisfy the look angles to the east and west locations of present and future TDRSS satellites, and will provide sufficient separation from the present terminal to guard against mutual exposure to catastrophic events or simultaneous communications interruptions from heavy rain. The two terminals are close enough, however, to share key personnel, technical support staff, and general logistic support. In this regard, the technical support facility included in this project will provide logistics and training space for both ground terminals, and will also provide permanent engineering and technical library space for the existing terminal.

IMPACT OF DELAY:

Delay of this project will delay the backup capability needed for the TDRSS ground segment, and continue the present ground terminal as a single point of failure for orbital spacecraft tracking and data support with potential for severe impact of national importance. Construction must begin in FY 1987 for facility availability to install the associated antennas and electronics in 1989.

PROJECT DESCRIPTION:

This project provides the necessary facilities for a complete TDRSS ground terminal at a location on White Sands Test Facility (WSTF) three miles north of the existing ground terminal (Figure 2). Included is an 84,000-square foot Main Terminal Building (Figure 3) for radio frequency equipment and related electronics, equipment and software maintenance, engineering documentation, and related support. Three antenna foundations and a water supply tank will be provided, and a 6,000-square foot emergency power plant will be installed as backup to commercial power. A security fence will surround approximately 40 acres containing the main terminal building, the foundations for three 60-foot diameter antennas, the water tank, and the backup power plant. Also included are the connections to the commercial utilities, a three-mile access road, area paving, grading, and drainage. A 28,000-square foot support building (Figure 5) will also be provided at the site of the existing ground terminal (Figure 4) for technical support logistics and procurement and for personnel offices, training, and guards associated with these ground terminals.

PROJECT COST ESTIMATE:

This cost estimate is based on a preliminary engineering report.

	Unit of Measure	Quantity	Unit Cost	Cost
Land Acquisition	---	---	---	---
Construction	---	---	---	20,547,000
Roads and paving	LS	---	---	1,780,000
Site work	LS	---	---	2,910,000
Main terminal facility	SF	84,000	121.67	10,220,000
Support building	SF	28,000	105.71	2,960,000
Emergency power plant	SF	6,000	356.17	2,137,000
Special structures	LS	---	---	540,000
Equipment	---	---	---	1,453,000
Emergency generators	LS	---	---	1,453,000
Fallout Shelter (not feasible)	---	---	---	---
Total				22,000,000

LIST OF RELATED GRAPHICS:

Figure 1 - Location Plan
Figure 2 - Main Terminal Building Site Plan
Figure 3 - Main Terminal Building
Figure 4 - Support Building Site Plan
Figure 5 - Support Building

OTHER EQUIPMENT SUMMARY:

Data systems including antennas and related electronic equipment and software will be provided with Spaceflight Control and Data Communication resources in the amount of $300 million during the FY 1987-FY 1991 period.

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

No future CoF funding will be required to complete this project.

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF THE SECOND TRACKING AND DATA RELAY SATELLITE SYSTEM
GROUND TERMINAL FACILITY, NEW MEXICO

MAIN TERMINAL BUILDING
SITE PLAN

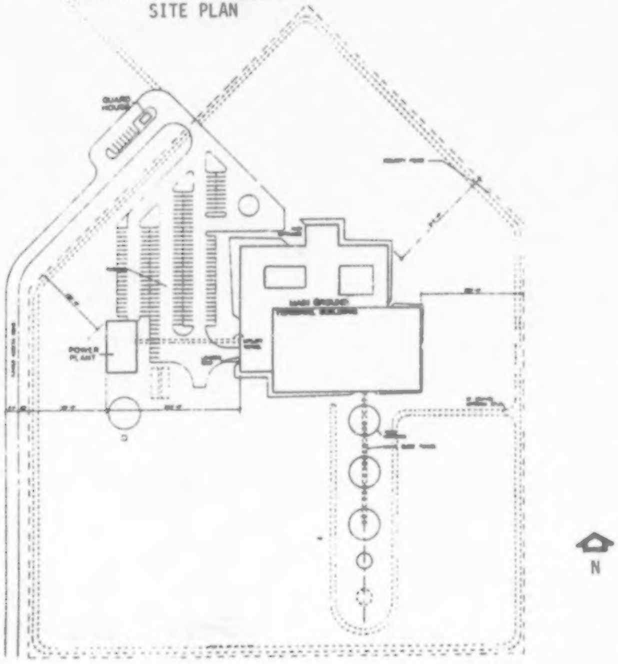
GUARD HOUSE
POWER PLANT
MAIN GROUND TERMINAL BUILDING
N

FIGURE 2

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF THE SECOND TRACKING AND DATA RELAY SATELLITE SYSTEM
GROUND TERMINAL FACILITY, NEW MEXICO

MAIN TERMINAL BUILDING

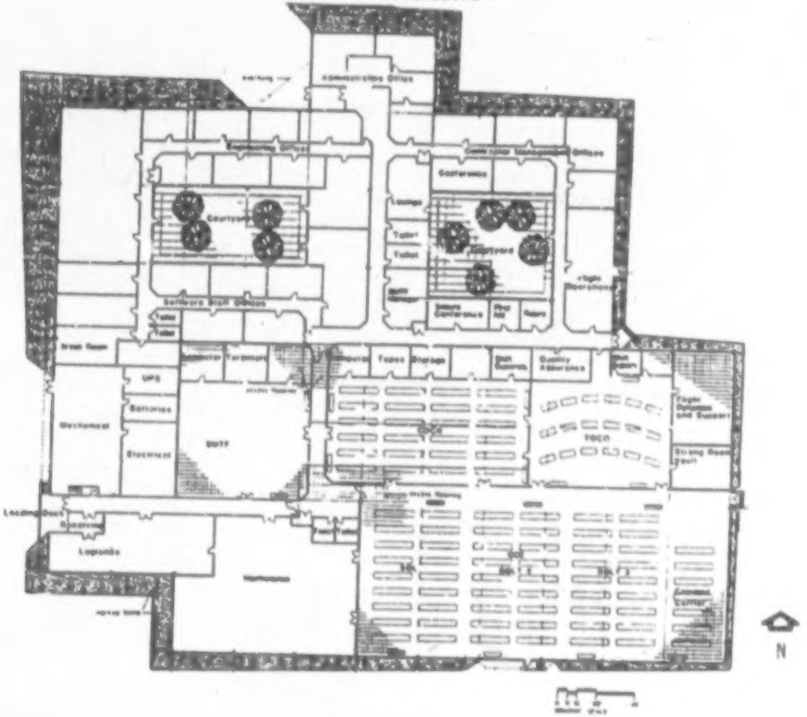
Administrative Office
Courtyard
Conference
Lounge
Toilet
Toilet
Courtyard
Software Staff Offices
Break Room
UPS
Batteries
Mechanical
Electrical
Tapes Storage
Quality Assurance
TOCO
Strong Room Vault
Loading Dock
Logistics
N

FIGURE 3

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF THE SECOND TRACKING AND DATA RELAY SATELLITE SYSTEM
GROUND TERMINAL FACILITY, NEW MEXICO

SUPPORT BUILDING
SITE PLAN

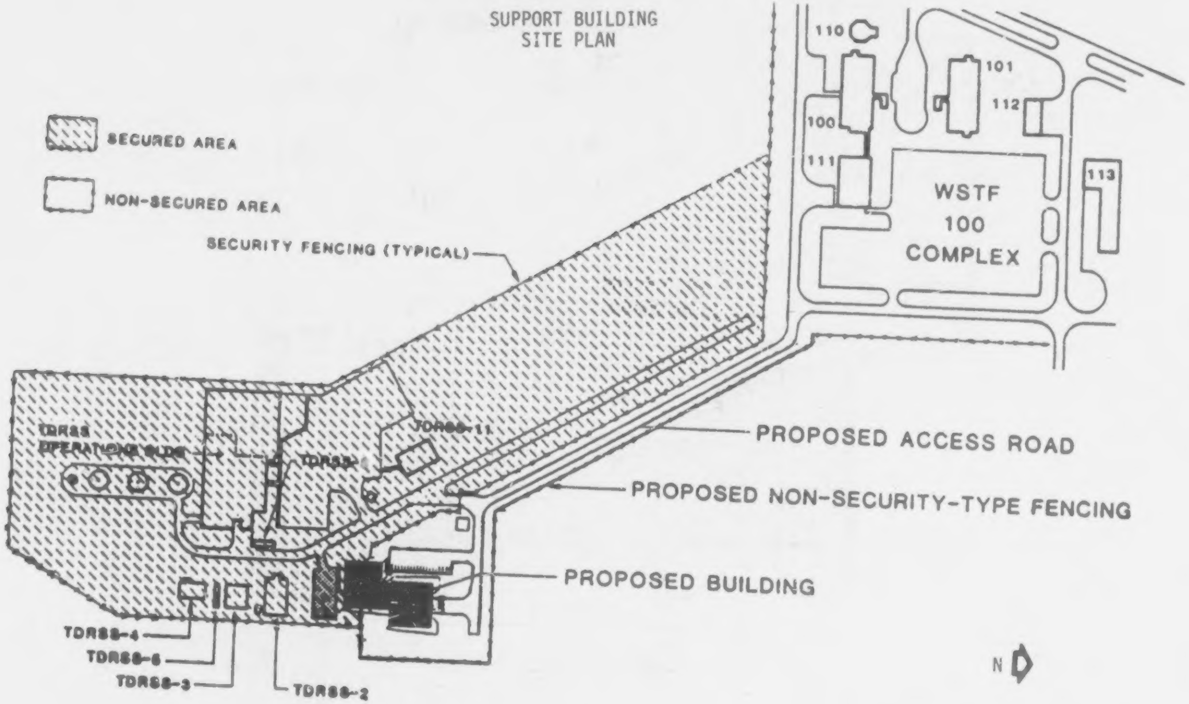
▨ SECURED AREA
☐ NON-SECURED AREA
SECURITY FENCING (TYPICAL)
110
101
112
100
111
113
WSTF
100
COMPLEX
TDRSS
OPERATIONS BLDG
TDRSS-11
TDRSS-
PROPOSED ACCESS ROAD
PROPOSED NON-SECURITY-TYPE FENCING
PROPOSED BUILDING
TDRSS-4
TDRSS-5
TDRSS-3
TDRSS-2
N

FIGURE 4

GODDARD SPACE FLIGHT CENTER
FISCAL YEAR 1987 ESTIMATES
CONSTRUCTION OF THE SECOND TRACKING AND DATA RELAY SATELLITE SYSTEM
GROUND TERMINAL FACILITY, NEW MEXICO

SUPPORT BUILDING

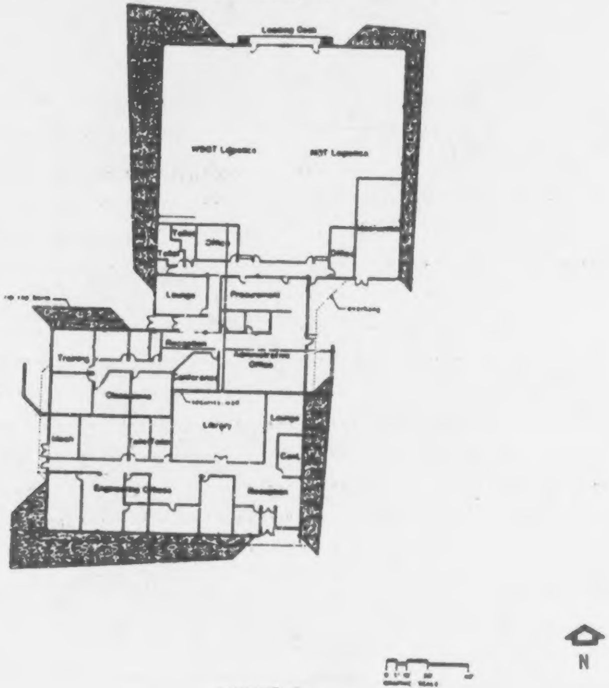
Loading Dock
WSGT Logistics
NGT Logistics
Office
Lounge
Procurement
overhang
Reception
Training
Administrative Office
Conference
Classroom
Library
Lounge
Mech
Engineering Offices
N
GRAPHIC SCALE

FIGURE 5

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1987 ESTIMATES
SUMMARY
REPAIR

Summary of Project Amounts by Location:	Amount	Page No.
Ames Research Center	2,150,000	CF 10-3
Dryden Flight Research Center	350,000	CF 10-4
Goddard Space Flight Center	2,180,000	CF 10-5
Jet Propulsion Laboratory	1,030,000	CF 10-6
Johnson Space Center	2,440,000	CF 10-7
Kennedy Space Center	3,175,000	CF 10-9
Langley Research Center	3,030,000	CF 10-11
Lewis Research Center	2,580,000	CF 10-12
Marshall Space Flight Center	2,570,000	CF 10-14
Michoud Assembly facility	400,000	CF 10-15
National Space Technology Laboratories	2,200,000	CF 10-16
Wallops Flight Facility	1,745,000	CF 10-17
Miscellaneous Projects Not Exceeding $150,000 Each	150,000	CF 10-18
Total	24,000,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE:	Repair of Facilities, Not in Excess Of $750,000 Per Project
INSTALLATION:	Various Locations
FY 1987 CoF ESTIMATE:	$24,000,000
FY 1985: $18,000,000	FY 1986: $22,000,000

COGNIZANT INSTALLATIONS/LOCATIONS OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Management

SUMMARY PURPOSE AND SCOPE:

These resources will provide for large repairs to facilities at NASA field installations and Government-owned industrial plants supporting NASA activities. Included in the request are those facility repair needs for FY 1987 that can be foreseen at the time of the submission of these estimates, and are not to exceed $750,000 per project. The thrust of this program is to provide a means to restore facilities or components thereof, including collateral equipment, to a condition substantially equivalent to their originally intended and designed capability. The request includes the substantially equivalent replacement of utility systems and collateral equipment necessitated by incipient or actual breakdown. This work also includes major preventive measures which are normally accomplished on a cyclic schedule of greater than 1 year.

PROJECT JUSTIFICATION:

A major portion of the Agency's facilities exceeds 20 years in age, and increases in repair requirements are to be expected. Maintenance and repair costs for mechanical and electrical systems in a typical building are almost three times higher during the 16- to 30-year period of a building's life than they are during the initial 15 years of beneficial occupancy. At about the 15-year point, many electrical and mechanical components reach the end of their serviceable or economic life and should be replaced in the interest of long-term economy. Continued piecemeal repair of these components usually requires more resources in the long run than replacement after the end of the economic life of the original components. Approximately 75 percent of the physical plant is in the 16- to 30-year old category.

The major thrust of this repair program, as well as the rehabilitation and modification programs, is to preserve the Agency's $3.6 billion (as of September 30, 1985) physical plant. The major distinction between these classes of work is whether or not the intended work is to bring the facility and its components to a condition substantially equivalent to its designed capacity, efficiency, and capabilities. If such is the case, the work is classified as repair. An analysis of each of the projects for which funds are requested indicates that this work must be addressed and progressively accomplished. Otherwise, risks are increased and future costs of the specific work will be greater. More importantly, there will be increased breakdown and costly unscheduled repairs required.

This program includes only facility repair work having an estimated cost not in excess of $750,000 per project. The work is of such a nature and magnitude that it cannot be accomplished by routine day-to-day facility maintenance and repair activities, or by related routine facility work efforts that are provided for in other than CoF estimates. A repair project, estimated to cost more than $750,000, would be reflected elsewhere as a separate major line item project.

PROJECT DESCRIPTION:

Proposed repair projects for FY 1987 totaling $24,000,000 are described under "PROJECT COST ESTIMATE." Projects estimated to cost not in excess of $150,000 have not been individually described or identified by Center, and the total request for these projects is $150,000. This repair program has been distilled from requests for FY 1987 exceeding $42,000,000, and thus represents a modest request in relation to the continuing backlog of this type of work. Based on relative urgency and expected return on investment, the projects which comprise this request are of the highest priority. Deferral of this mission-essential work would adversely impact the availability of critical facilities and program schedules.

During the course of the year, it is recognized that some rearrangement of priority may be necessary. This may force a change in some of the items to be accomplished. Any such change, however, will be accomplished within total available repair resources. The following broad categories of work are described further in the "PROJECT COST ESTIMATE":

a. Utility Systems	10,650,000
b. General Purpose Buildings	1,325,000
c. Technical Buildings/Structures	6,655,000
d. Pavements and Drainage	2,710,000
e. Building Exteriors and Roofs	2,660,000

PROJECT COST ESTIMATE:

A. Ames Research Center (ARC)	2,150,000
1. Repair of 11 x 11-Foot Transonic Wind Tunnel	745,000

The tunnel aftercooler coils and fin tube oil heat exchanger are over 25 years old. Both have required excessive repair and down time because of age and corrosion. Tunnel flow quality is degraded due to hot spots caused by sections of the cooling coils being sealed to stop leaks. Contamination of compressor lubricating oil by cooling water causes down time and risks compressor bearing damage. This project will replace about one quarter of the coils in the tunnel aftercooler. It will also replace the fin tube heat exchanger in the oil house with plate type heat exchangers. Automatic controls will insure constant oil temperature during tunnel operation.

2. Repair of 7 x 10-Foot Wind Tunnels	745,000

These two 45-year old wind tunnels have flat roofs and cross sections. Rain water ponds on the flat top surfaces and on the flat side stiffeners where they connect to the tunnel skin. This frequent water accumulation has created extensive corrosion, which has weakened the tunnel's half-inch steel plate skin and the structural cross bracing. Expansion due to rust has buckled some structural bracing and has opened welded joints. This project will repair or replace buckled structural members, remove corrosion by sandblasting, reweld joints where needed, modify drainage to prevent water accumulation, and provide corrosion resistant painting.

3. Repair of Protective Coatings for Thermo-Physics Facilities............................ 380,000

This project provides for cleaning, surface preparation, and corrosion resistant painting of the support structure and major elements of the steam ejector vacuum system (building N-234A), 3.5-Foot Hypersonic Wind Tunnel (N-229), High Reynolds Channels (N-231), and six 75-foot diameter vacuum containment vessels. The exteriors of these structures have not been cleaned and treated in over ten years. Recent inspection has uncovered extensive corrosion caused by salt, air, rain, and fog. Delay in arresting this progressive corrosion will lead to costly future repairs. A break in the structural integrity of the large vacuum spheres would render them useless and require costly emergency repair.

4. Repair of High Pressure Air Compressor Cooling Systems................................ 280,000

The C1D Compressor provides about one-half the total high pressure air capacity for Ames Research Center. Pressurization of the air creates large quantities of heat, which is removed by air or water cooled heat exchangers stationed between each of the five stages of compression. The heat exchangers were not new when installed 10 years ago and have required extensive repairs since then. One of these exchangers now has a cracked head and they all require major overhaul. This project provides for rebuilding, replacement, and addition of heat exchangers and associated cooling equipment necessary for continued reliable operation of Compressor C1D.

B. Dryden Flight Research Facility (DFRF)... 350,000

1. Repair of Roads and Parking.. 350,000

Pavement in the employee parking area is cracked and differential settlement is prevalent. Pavements in the warehousing, shop, and other parking areas have begun to fail due to age and wear. The road to the aircraft apron is severely distressed due to heavy traffic. Continued progressive failure of these pavements will cause deferred repair to be more expensive and will risk foreign object damage to aircraft on the nearby apron. The paving provided by this project will be a 1.5-inch overlay on the parking lot, a 5-inch replacement for the aircraft apron road, and a 1.5-inch or 3-inch overlay, as required, in the warehouse, shop, and other parking areas.

C. Goddard Space Flight Center (GSFC).. 2,180,000

1. Repair of Main Breakers, Various Buildings... 500,000

This project provides for the replacement of three main breakers and one tie breaker in the Launch Phase Simulator Facility (Building 15) and the Network Test and Training Facility (Building 25) and replacement of 46 feeder circuit breakers in the 120/208 volt switchgear in Building 25. The main breakers and the feeder circuit breakers were installed in the mid-1960's as part of the original building electrical equipment. Due to the worn condition of the spring force retention parts of the main breaker, it can plunge into closed circuit position without manual activation during reset. This sudden closing of the power circuits would create a dangerous condition for the maintenance personnel working on the system. The breaker manufacturer has ceased production of replacement parts because the equipment is obsolete. The replacement of entire breaker units is necessary to insure continued safe and reliable operation.

2. Repair Air-Handling Units in Various Buildings...................................... 335,000

This project provides for the repair/replacement of 8 air-handling units (AHU) in the Meteorological Systems Development Laboratory (Building 21) and the NASA Space Science Data Center (Building 26). Also, plenum, ductwork, piping, defective dampers, and automatic temperature control instrumentation panels will be repaired as necessary. The existing package/built-up air handling units have been in operation since the early 1960's. Due to deterioration and corrosion resulting from their long and heavy use, replacement of components or the entire unit has become necessary. The proposed work will improve operational efficiency, reduce maintenance cost, and enhance system reliability.

3. Repair of Roof, Space and Terrestrial Applications Facility.......................... 345,000

This project provides for the replacement of 39,000 square feet of roof on the Space and Terrestrial Application Facility (Building 22). Coping, flashing, gravel stop, and other accessories will be replaced as part of the project. The roof is more than 20 years old and contains numerous patches and temporary repairs and is showing signs of general age deterioration. The proposed work will restore facility integrity and reduce the risk of property loss due to water damage.

4. Repair Elevators, in Various Builidngs... 280,000

This project provides for the repair and refurbishment of four elevators, one car each in the Space Sciences Laboratories (Building 6), the Applied Sciences Laboratory (Building 11), the Payload Testing

Facility (Building 7), and the NASA Space Science Data Center (Building 26). The repair work includes the refurbishment/replacement of elevator cabs, doors, controls, related equipment, and all worn parts. Provisions for the handicapped and emergency fire access are also included. These passenger/freight elevators have been in constant use since the 1960's for transporting both personnel and equipment. Heavy use, especially from carrying equipment, has caused the elevators to be frequently out of service. This can be for prolonged periods due to the difficultly in obtaining parts for the outdated elevators. This project will restore dependable service and reduce repair and maintenance costs.

5. Repair of Cooling Tower B.. 720,000

This project provides for the repair and replacement of cooling tower equipment including structural framing, basin, decking, fill, water distribution headers, nozzles, drift eliminators, partitions, electrical controls, valves and piping. The installation of flow measuring devices in the tower risers are also included. Cooling Tower B is a 9,000-ton capacity tower and has been in service since 1965. Due to age and deterioration resulting from continuous operation, a complete restoration is required. The tower supports the Central Refrigeration Plant and the chilled water distribution system which are critical elements to successful mission operations at GSFC. The proposed repair work must be implemented to insure chilled water system efficiency and reliability.

D. Jet Propulsion Laboratory (JPL).. 1,030,000

1. Repair HVAC System, Procurement Office.. 560,000

This project provides for the replacement of six deteriorated and unreliable direct expansion (DX) type HVAC systems in the Procurement Office (Building 190). The existing air handling units are 17 to 24 years old. A new central chilled water system will be provided for both the first and second floors. This new system will supply chilled and hot water to new energy efficient air handling units equipped with economizer cycles. Most of the existing supply and return distribution ductwork is salvageable and will be reused. The existing inedquate restroom ventilation systems will also be replaced. The consolidation of these systems and changing from DX type to chilled water type systems greatly improve the reliability and versatility of this building's HVAC support and also reduce energy and maintenance costs.

2. Repair HVAC System, Combined Engineering Support Building.............................. 470,000

This project will provide for the repair of the existing HVAC system in the Combined Engineering Support Building (125), including the replacement of deteriorated equipment and improvements to system operations. This building is 33 years old and the original air handlers are rusting, have become unreliable and are difficult to maintain. The major items of work include: replacement of the air distribution ducts from the three major air handling units to permit more efficient control of air flows; replacement of a multizone air handling unit located in the penthouse equipment room; installation of two roof-mounted units which will be connected to existing ductwork; replacement of two deteriorated hot water boilers; and the modification of the existing chilled water distribution system to a variable flow pumping system. All of the above repairs will result in a more energy efficient, reliable and less costly to maintain HVAC system.

E. Johnson Space Center (JSC)... 2,440,000

1. Repair of Chillers, Various Buildings.. 250,000

This project provides for the repair of four chillers located in the Central Heating and Cooling Plant, Building 24 and the Emergency Power Building 48. Work includes the replacement of compressor rotary assemblies and various internal components for two chillers in Buiding 24 and two chillers in Building 48. This repair work is necessary to maintain the reliability and efficiency of the chillers which are approximately 24 years old and in need of a major overhaul.

2. Repair Heating, Ventilating, and Air-conditioning Systems, Various Buildings........... 475,000

This project includes the repair and/or replacement of deteriorating air-handler casings and structures, compressors, condensers, etc. Other tasks that will be performed include coil cleaning, damper and duct repair and insulating. the area of concentration will include Buildings 10, 14, 16a, 29, 32, and 49. This project is necessary because aging, high humidity, and salt/chemical content of the air in the JSC area have resulted in a rapid deterioration of these systems beyond the point where routine maintenance can keep them functioning.

3. Repair Electrical Substations, Various Buildings...................................... 435,000

This project provides for replacement of a 1,000-KVA transformer in Building 33 and the replacement of six 15-kV oil-filled switches, three in Building 5 and one each in Buildings 15, 33 and 44. Three secondary main breakers will also be replaced. The electrical equipment in the substations is approximately 22 years old and the environment has caused them to deteriorate to a point beyond which normal maintenance can keep them operating in a safe manner. If this equipment is not replaced, substation reliability will degrade and JSC programs could be adversely affected.

4. Repair Deluge Fire Protective System, White Sands Test Facility (WSTF).................. 265,000

This project provides for repair of the deluge fire protection system at the White Sands Test Facility (WSTF). The water deluge system provides protection in the area 300 and area 400 propulsion test stands and extends to the fuel and oxidizer storage and distribution areas, the chemical steam generator installation, and the alcohol storage tank. Existing carbon steel pipe will be replaced or lined and various valves, manifolds and components will be repaired and/or replaced and serviceable lines will be cleaned. The existing deluge fire protection system was installed in the early 1960's and repair work is now required to return the system to a reliable operating standard.

5. Repair of 15-kV Power Cable, Utility Tunnel System.................................... 490,000

This project provides for repair by replacement of electric power feeders 1-6 and 1-8 in the utility tunnel system. The work includes the replacement of approximately 7,000 linear feet of 15kV cable servicing Buildings 4, 5, 7, 7a, 8, 9, 10, 11, 29, 31, 33, 35, and 37. This electrical power cable has been in continuous operation for 20 years. Recently, numerous unscheduled outages have occurred because of faults in the cable system. Examination of the cable indicates that replacement is required to insure electrical power reliability to the critical facilities served by this cable system.

6. Repair of Roofs, Various Buildings... 350,000

This project provides large area roof repairs for ten Buildings. The normal aging process, together with various building modifications affecting the roofs, and the presence of numerous roof penetrations have resulted in leaks and moisture accumulations in the existing roofing materials. Approximately 27,000 square feet of roofing on Buildings 9 and 31, and a total of 34,000 square feet of roofing on Buildings 13, 15, 16, 17, 31, 49, 265 and 356 will be replaced. The metal roof sheeting on Building 29 will be coated with a spray foam roof system. This project is needed to preclude damage to the building structure, as well as damage to interior ceiling panels, electrical panels, and sensitive equipment contained in the building.

7. Repair Potable Water Storage Tank.. 175,000

This project provides major repair to the deteriorating one-million gallon, above ground potable water storage tank No. 1. Severe corrosion in the structural framing of the tank will result in eventual structural failure. Repairs include sandblasting the underside of the roof decking, and replacement of existing tank rafters and girders with new structural framing members. The new members and the clean roof underside will be painted. Tank cathodic protection will also be provided.

F. Kennedy Space Center (KSC).. 3,175,000

1. Repair O&C Building Substations.. 395,000

This project provides for the refurbishment of the Operations and Checkout Building substations A,B,C,D,E,F,OZ and OY which are over 20 years old and are experiencing corrosion and rapid deterioration due to the harsh environment. Most corrosion is in the base of transformers and switch gear cabinets, which cannot be corrected by routine maintenance. Under this project the substations will be dismantled, structurally restored, painted and reinstalled. Circuit breakers and major connections will be replaced. Without these repairs, there is a high probability of a structural failure or an electrical failure caused by water intrusion with an attendant interruption in STS cargo processing.

2. Repair LCC Firing Room and Vestibule Windows.. 155,000

This project will remove the existing 370 glass panels (4 x 5 feet), replace deteriorated gasket material and glazing sealant and reinstall the panels. The project will also replace approximately 75 cracked glass panels with new 3/4 inch thick laminated glass. These repairs are required because of accrued deterioration caused by weathering conditions. If not repaired, water infiltration will cause damage to the electronic equipment located near the windows.

3. Repair Base Support Building Roof... 265,000

This project will repair 75,000 square feet of conventional 5-ply built-up roof on the Base Support Building. The work consists of removing all loose gravel, inspection to identify deteriorated conditions, repair blisters, breaks, buckles; then replacing deteriorated felts, repair of base flashing around ventilators, treatment of the entire roof surface with asphalt base resaturant, and replacement of gravel. Failure to provide repair of this deteriorating roof will result in damage to the ceiling, walls and equipment in this building.

4. Repair Communications Office Building Air-Conditioning System.......................... 490,000

This project will replace the 20-year old air-conditioning system in the Communications Office Building. The new unit will have a nominal rating of 80 tons. New air handlers, compressors, outdoor condensers and modification to the duct system will also be included. The existing system is inefficient, components are unreliable, and replacement parts are difficult to obtain. Repair must be effected now before a major breakdown totally disrupts the communications operations.

5. Replace Water Chillers and Pumps at Flight Crew Support Building........................ 280,000

This project provides for replacement of two existing HVAC water chillers and two chilled water pumps with two new 160-ton water cooled chillers and two 300 gpm chilled water pumps. Associated controls and piping in the Flight Crew Training Building (FCTB) will also be replaced. This project is required due to the unreliability of the existing HVAC equipment used in support of the launch processing system computers in the FCTB. This project will improve reliability and reduce maintenance costs over the life of this equipment.

6. Repair Hangar "AE"... 470,000

This project provides for general repair of air-conditioning chillers and piping, and replacement of approximately 34,000 square feet of flooring in Hanger "AE", CCAFS. In addition, selected windows, doors, and walls will be refurbished and the fire alarm system modified to meet fire protection standards. This facility includes an important clean room which is used for payload processing. The air-conditioning system and interior of this building has deteriorated beyond correction by normal maintenance and requires general repair to satisfactorily handle the processing of costly payloads.

7. Repair VAB Low Bay Built-up Roof... 460,000

This project will repair approximately 120,000 square feet of the conventional 5-ply built-up roof system of the VAB low bay. The work required consists of: removal of all loose gravel, inspection to identify deteriorated conditions, repair blisters, breaks, buckles, treatment of entire roof surface areas with asphalt base resaturant and replacement of gravel. Failure to provide repair will result in further deterioration that will damage the ceiling, walls and equipment in this program critical building.

8. Repair NASA Parkway - Kennedy Parkway to Gate #3...................................... 660,000

This project repairs approximately 7.5 miles of the westbound lanes of NASA Parkway from Kennedy Parkway to Gate #3. Approximately 2,635 tons of asphalt concrete will be required as a leveling course due to settlement of the roadbed. The repair includes a 1-inch asphaltic concrete overlay covering some 105,000 square yards of paving. This road is more than 15 years old and is subjected to heavy traffic which includes cars and buses that transport the heavy visitor load (approximately 2,000,000 per year). The roadbed and surface deterioration is accelerating and higher repair costs will be incurred if these repairs are deferred.

G. Langley Research Center (LaRC).. 3,030,000

1. Repairs to High Pressure Systems, Hypersonic Blowdown Tunnels........................ 550,000

This project provides for repairs to high pressure systems in the Hypersonic Blowdown Tunnels. The work includes: replacement of defective piping, valves and fittings, and inspection/repair of defective welds. These systems have been analyzed and inspected as part of LaRC's on-going recertification program and have been determined to be defective and potentially unsafe. This project will restore these systems to within safe operational parameters.

2. Repair of Roof Building 1202.. 550,000

This project will replace approximately 57,000 square feet of existing built-up roofing at Building 1202. Repairs will include removing all existing roof material, providing new insulation, flashing, and all other materials necessary to restore the roof to its original condition. Severe roof leaks continue to occur due to rapid deterioration caused from expansion of water vapor trapped between existing roof layers. Normal maintenance is no longer a viable option.

3. Repairs to 30 x 60-Foot Tunnel.. 730,000

This project provides for the replacement of obsolete circuit breakers in the 30 x 60-foot tunnel main drive switchgear and for the replacement of approximately 40,000 square feet of roof at the north end of the building. The switchgear work requires removing the existing breakers, installing new circuit breakers, and reconnecting cables. The circuit breakers are no longer commercially available, therefore any failure means lengthy downtime until replacement parts can be custom made. The existing corrugated asbestos roof will be replaced with a metal roof, drains located in the roof valley will be enlarged, and other related repairs will be made. The roof was installed in 1931 and has become brittle with age causing many water seals to break. Normal maintenance can no longer keep it from leaking.

4. Repairs to High Pressure Systems... 450,000

This project provides for repairs to the high pressure air, nitrogen and helium systems in the High Speed Aerodynamics Complex at Langley Research Center. The work to be done under this project includes: replacement of defective piping, valves and fittings, inspection of welds, and repair of defective welds. These systems have been determined to need repair under LaRC's on-going pressure system recertification program. Much of the piping, valves, and welds do not meet applicable codes and center safety criteria and must be repaired for continued safe operation.

5. Repair Electrical Switchgear, Various Facilities.. 510,000

This project provides for the replacement of switchgear "C" in Building 1220, switchgear "B" in Building 1201, switchgear "A" in Building 1205, and a day panel (cubical No. 1) in Building 1230. The work requires disconnecting cables feeding existing loads, removing the panels to be replaced, installing new panels, and reconnecting the existing cables. The switchgear to be replaced under this project contains circuit breakers which are no longer manufactured. Procurement of spare parts is very difficult and they can only be obtained after very long delivery periods. New circuit breakers will eliminate the risk of extensive downtime and insure a safer and more reliable protection system.

6. Repair Cooling Towers, Various Locations.. 240,000

This project provides for the replacement of cooling towers at Buildings 1212, 1146, 1148, and 1230. The cooling towers range in capacity from 150 GPM to 1200 GPM. The work to be accomplished will include demolishing the existing cooling towers, replacing or modifying the basins, piping and electrical services as required, and installing new tower structures. These cooling towers are very old and in very bad condition. Maintenance has become costly and ineffective. Replacement is essential to ensure uninterrupted service to the facilities.

H. Lewis Research Center (LeRC)... 2,580,000

1. Repair Process System for Recertification.. 335,000

This project provides for the repair to the 45 PSIG combustion air system piping by replacing and repairing various piping components that do not comply with current pipe and pressure vessel codes. The work includes replacement of three 20-inch relief valves, replacement of ten aftercooler pipe bundles and replacement of thirty pipe supports. This project is part of a planned program to ensure safe operation of pressurized systems at the Lewis Research Center. The system in this project supports approximately 15 research facilities and is more than 30 years old. The repairs are needed to maintain structural integrity and system reliability in support of vital aeronautical research activities.

2. Repair Domestic Water Systems, Various Buildings.. 415,000

This project provides for the separation of domestic and nondomestic water distribution systems in various portions of the LeRC potable water distribution system including Buildings 3, 4, 9, 14, 24, 50, 77 and 102. The work includes the removal of the existing domestic water system; installation of new pipes, valves, fittings and insulation; installation of backflow prevention devices and removal of asbestos insulation. This project is part of a planned program to upgrade the domestic water system and remove the hazards created by cross connections between domestic/non-domestic systems and the possibility of backsiphoning.

3. Repair of Air Dryer Bed, 8 x 6-Foot Supersonic Wind Tunnel (SWT)........................	695,000

This project provides for repairs to the air dryer bed at the 8 x 6-foot SWT, Building 57. Air dryer beds are required to preclude excessive moisture from entering the tunnel air flow and disrupting test conditions. The work in this project includes removal and reinstalling the desiccant; installation of new desiccant screens and repairs to the structural supports. Deterioration of the support screens have adversely impacted the testing capability of the tunnel and failure of the dryer beds are causing frequent testing delay. This project will provide repairs to the deteriorated dryer beds to prevent further disruptions to the tunnel operations.

4. Repair of Air Systems, Engine Research Building..	635,000

This project provides for repairs to the process and combustion air systems in the Engine Research Building 5. The work includes replacement of deteriorated isolated valves/actuators in the process air system and repair/modifications to the 24-inch combustion air line. The valves, actuators, and piping in these air systems are over 30 years old and have required constant maintenance. Despite the maintenance efforts, these systems no longer function adequately, are a potential safety hazard, and have a negative impact on research test results. Replacement of these valves and repair to these systems are necessary to ensure the safety of personnel/equipment and to maintain operational efficiency.

5. Repair of Roof, Fabrication Building...	290,000

This project consists of the repair of approximately 47,000 square feet of roof on the Fabrication Building 50. The work includes the removal of all roofing material and penetrations. Existing roof penetrations will be reconstructed to current standards. Obsolete roof equipment out of service and no longer needed will be removed. A Class A fire underwriters approved roofing system will be installed with the necessary roof insulation to meet current ASHRE standards. Roof surfaces in pedestrian traffic areas will be protected with roof walkways. These 20-year old roofs, despite periodic routine maintenance, have deteriorated to the point where extensive repair is required to prevent damage to the building structure and equipment therein.

6. Repair of Main Water Distribution System, Plum Brook.................................. 210,000

This project will repair portions of the main water distribution system at the Plum Brook Station. The work in this project includes the repair of raw water supply lines, the replacement of the raw water diesel booster pump, the modification and extension of the domestic water system to the Engineering Building, and the repair or replacement of shut-off valves and hydrants. The water distribution components being repaired are major elements of the Plum Brook water and fire protection systems. The systems are approximately 45 years old and are in need of significant repair. This project will allow the water distribution system to continue to operate in a safe and reliable manner and will insure the health and fire protection integrity of the Plum Brook Station.

I. Marshall Space Flight Center (MSFC).. 2,570,000

1. Repair Pressure Vessels, Increment II.. 710,000

This project provides for repair of high pressure vessel defects identified during a safety survey of the pressure systems. Two large 6,000 cubic foot compressed air vessels (one 400 psi and the other 125 psi) and eighteen 35-cubic foot high pressure air vessels (3500 psi to 5000 psi) will be repaired. These pressure vessels store a large volume of high pressure air that support test programs. It is essential that the structural integrity of these vessels be maintained. Loss of this air storage capacity would impact all major test programs at MSFC.

2. Repair High Pressure Piping.. 700,000

This project provides for the replacement of 25- to 30-year old high pressure piping systems. Work includes the replacement of approximately 5,000 linear feet of 3-inch gaseous nitrogen (GN_2) pipe lines connecting the generation plant to the East Test area. Also included is the replacement of the GN_2 manifold at bottle battery 4598 and related work. This manifold connects eleven 5,000 psi storage vessels which serve the East Test area. This project is part of a plan to repair deteriorating pipeline systems which support vital laboratory and testing activities at the center. This effort will eliminate potential hazards due to corrosion and possible leakage that can occur adjacent to inhabited buildings. These 25- to 30-year old systems are exceeding their design life and increasing failure rates are being experienced.

3. Repair Roofs, Various Buildings.. 485,000

This project provides for repairing approximately 3,800 squares of roofing for various Buildings including 4249, 4670, and 4752 at MSFC. Work includes installation of new roof systems with insulation, flashing, expansion covers, control joints, gravel guards, and pitch pockets over existing roof decks. Also included will be the rehabilitation of vents and hatches, roof deck repairs, and recoating existing roofs of several buildings. Spot repairs are no longer effective nor economical. Some roofs are weathered, dried out, and have soft spots where insulation is saturated. To alleviate these problems, and to preserve the structures, these roofs must be repaired.

4. Repair HVAC Systems, Various Buildings... 420,000

This project is part of a planned program to repair major HVAC equipment in Buildings 4494, 4654, 4659, 4670, and 4674. This work includes the repair or replacement of chillers, cooling towers, and air-handling units. Also included is the replacement of direct expansion air-conditioning units, pumps, compressors, and other related work in several buildings. The HVAC equipment is in a deteriorated condition and requires continual maintenance to keep it operable. It is more economical to replace major items of HVAC equipment than to continue repairs. These facilities are essential to the operations at the center and the repair of these HVAC systems is urgently needed at this time.

5. Repair Exterior, Various Buildings... 255,000

This project provides for the exterior repair of approximately 350,000 square feet of building wall and surfaces for various buildings. Work includes surface preparation and application of a protective coating, repair or replacement of gutters, downspouts, windows, doors, and related work. Exterior repair is required to protect these buildings from the cumulative damaging effects of deterioration and will preserve these facilities for continued operation. The installation of new exterior siding with insulation will reduce energy consumption, maintenance, and short term repair efforts.

J. Michoud Assembly Facility (MAF)... 400,000

1. Repair Barge Dock... 400,000

This project provides for repairs to the MAF Barge Dock, where the External Tanks are loaded on to barges and shipped to the launch sites. The work consists of structural restoration of the east and west docks; rehabilitation of electrical service; dock surface pavement repairs; and new lighting. Structural restoration includes timber and fender replacement. The Barge Dock area is too deteriorated for effective corrective maintenance and requires a complete repair. This project will restore the operational reliability of the barge dock area, and reduce recurring maintenance costs.

K. National Space Technology Laboratories (NSTL).. 2,200,000

1. Repair of Complex B-2 Water Chilling System.. 700,000

This project provides for replacing two existing high temperature hot water absorption chillers (175 tons each) in the B-2 complex test control center, Building 4210, with one electrically driven centrifugal water chiller (250-ton). The pumping system will be interconnected to a chiller located in the Data Acquisition Facility, Building 4995 to provide emergency backup and peak load performance. The absorption units have been in continuous use for approximately 20 years. Similar units in other buildings have failed in the past 4 years because of deterioration. Replacement of the units now will preclude a major failure and provide the most energy efficient operation at the lowest life cycle cost while maintaining essential service to these mission critical facilities.

2. Repair 13.8 kV Submarine Cable.. 490,000

This project replaces six of ten 13.8 kV submarine cable crossings in the main canal. All electrical power is supplied to NSTL through six (6) individual 13.8 kV circuits. The existing ten cable crossings were installed in the mid-1960's and have exceeded their life expectancy. At this time, only six of the ten original cables are in service because of deterioration and failures to the cable system. With this serious deterioration to the in-service cables, and no spare cable capacity, any failure would result in a lengthy outage which could adversely affect SSME test operation. To assure continuity of electric service to NSTL, it is mandatory that reliable canal cable crossings be made available.

3. Repair Primary Roads.. 500,000

This project provides for 52,500 square yards of a 1-1/2 inch bituminous overlay on the north and southbound lanes of Road "A" from the south gate of the Mississippi Army Ammunition Plant to two miles south. This road, which is the main artery for access to NSTL, is rapidly deteriorating with numerous cracks and dips indicating subsurface breakdown and checkering and shoulder deterioration. A traffic signal will also be installed at the intersection of Roads A and J to improve traffic flow patterns. In addition, two low sections of the lower Gainville Road will be elevated to eliminate annual spring flooding which has reached up to six feet in depth.

4. Repair of Heating, Ventilating, and Air-Conditioning Components, Various Buildings...... 280,000

This project provides for the repair to the heating and cooling equipment in various buildings. The work includes replacement of the split system heat pumps and air-conditioning units in seven (7) buildings and the replacement of rotating equipment on packaged chillers in seven (7) other buildings. Replacement of associated control and ancillary equipment will also be provided. These buildings house the Administrative, Engineering, Research and Development and Support activities at NSTL. The HVAC units have been in continuous use for more than 20 years and require continuous maintenance. These units have exceeded their expected service life, of 15 years for split system heat pumps and air-conditioning units, and 20 years for water chillers. Replacement of these units is a cost effective way to reduce maintenance costs, preclude major system failures, and provide a reliable HVAC system.

5. Repair of Chiller Unit Building 4995.. 230,000

This project provides for the replacement of a 315-ton absorption chiller with an electrically driven 200-ton chiller unit at the Data Acquisition Facility, Building 4995. Modifications will include the installation of circulating pumps, and the addition of electrical services to accommodate the new electrically driven equipment. The absorption chiller has been in continuous use for more than 20 years and has had significant repairs to maintain satisfactory operating condition. Replacement of the absorption units with electrically driven units will provide an energy efficient and more cost-effective system.

L. Wallops Flight Facility (WFF).. 1,745,000

1. Repair Runway 4/22 Test Section Pavement.. 725,000

This project provides for the repair of Runway 4/22 at the Wallops Flight Facility. This runway is fully instrumented for aeronautic research and has special landing surfaces including transverse grooved areas and a flat section which allows a pool of water to be created for anti-skid research. These special features have hastened the deterioration, and repairs are mandatory to ensure continued safe runway research and operations. This project provides for the resurfacing of approximately 750,000 square feet of surface and the milling and refilling of deep cracks caused by water seepage. In addition, the special grooving required for the research must be redone. These repairs are required at this time for continuing anti-skid research.

2. Repair Paved Surfaces at the National Scientific Balloon Facility
Palestine, Texas.. 300,000

This project provides for the resurfacing and repair of the balloon launch pad area, roadways and parking lots. These areas include approximately 100,000 square feet of surface. One-half of this area will require overlay seal coat. The launch pad at NSBF is the active balloon launch area. Its surface is eroded by the launch process and requires repair and resurfacing at 5-year intervals (last done 1982). The roadways, which are primarily used for payload and balloon transportation and secondarily for personnel transportation, have deteriorated. They must be maintained to provide transportation to and from the launch area. The parking lots are also in a poor state of repair. The majority of these surfaces are part of the original construction of NSBF and are approximately 20 years old.

3. Repair Island Causeway Road..	250,000

The 25-year old causeway road which connects the WFF mainland with the island has not been repaired or resurfaced in 20 years. This project consists of the repair of existing pavement deficiencies, including cracking, settlement, and heaving, and the resurfacing of 2 miles of causeway (20 feet wide) with a base coarse and surface coarse. The resurfacing is necessary due to environmental deterioration which has embrittled the bitumen pavement, and cracking and settlement that is the result of years of use.

4. Repair Island Sewage Ejector Stations..	245,000

This project calls for the replacement of five sewage ejector systems located at the north and south ends of Wallops Island. They function as the intermediary system between the gravity collection system and the sewage treatment lagoons. The present 20 year old ejector systems function poorly and require excessive maintenance. Due to the age of the system, parts are not readily available and require long lead times for delivery. Procurement of electric ejector systems will increase efficiency, decrease maintenance costs and man-hours, and provide the necessary capability for environmentally safe sewage disposal.

5. Repair Buildings at the National Scientific Balloon Facility Palestine, Texas..	225,000

This project provides for the replacement of 31,500 square feet of roof on the Operations Building and the roof and metal side panels on the STRATOPORT I Building. Associated accessories and flashings will be replaced as part of this project. Both buildings are 21 years old and the roofs are showing signs of general deterioration. The metal side panels on the STRATOPORT I Building are of the same age and have experienced similiar deterioration. The proposed work will restore facility integrity and minimize potential property loss due to water damage.

MISCELLANEOUS PROJECTS LESS THAN $150,000 EACH	150,000
Total	24,000,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

An estimated 25,000,000 to 30,000,000 per year will be required for the continuation of this essential repair program.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONSTRUCTION OF FACILITIES
FISCAL YEAR 1987 ESTIMATES
SUMMARY
REHABILITATION AND MODIFICATION

Summary of Project Amounts by Location:	Amount	Page No.
Ames Research Center	1,795,000	CF 11-3
Dryden Flight Research Center	1,195,000	CF 11-3
Goddard Space Flight Center	2,110,000	CF 11-4
Jet Propulsion Laboratory	2,070,000	CF 11-6
Johnson Space Center	3,865,000	CF 11-7
Kennedy Space Center	3,035,000	CF 11-9
Langley Research Center	2,895,000	CF 11-11
Lewis Research Center	2,970,000	CF 11-13
Marshall Space Flight Center	3,840,000	CF 11-14
Michoud Assembly Facility	2,010,000	CF 11-16
National Space Technology Laboratories	1,440,000	CF 11-18
Wallops Flight Facility	1,430,000	CF 11-18
Various Locations	665,000	CF 11-20
Miscellaneous Projects Not Exceeding $150,000 Each	680,000	CF 11-20
Total	30,000,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE: Rehabilitation and Modification of Facilities, Not In Excess of $750,000 Per Project

INSTALLATION: Various Locations

FY 1987 CoF ESTIMATE: $30,000,000

FY 1985: $22,000,000 FY 1986: $26,000,000

COGNIZANT INSTALLATIONS/LOCATIONS OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Management

SUMMARY PURPOSE AND SCOPE:

These resources will provide for the rehabilitation and modification of facilities at NASA field installations and Government-owned industrial plants supporting NASA activities. Included in this request are those facility rehabilitation and modification needs for FY 1987 that have been fully identified at the time of the submission of these estimates, and are estimated not to exceed $750,000 per project. The purpose of this program is to restore or enhance the condition of a facility so that it can more effectively accomplish its designated purpose or increase its functional capability.

PROJECT JUSTIFICATION:

Based on the initial investment costs, the NASA Capital Type Property totals approximately $7.2 billion (September 30, 1985), of which the physical plant comprises some $3.6 billion. A continuing program of rehabilitation and modification of these facilities is required to:

a. Protect the capital investment in these facilities by minimizing the cumulative effects of wear and deterioration.

b. Ensure that these facilities are continuously available and that they operate at peak efficiency.

c. Improve the capabilities and usefulness of these facilities and thereby mitigate the effects of obsolescence.

d. Provide a better and safer environment for all personnel.

This program includes only facility rehabilitation and modification work having an estimated cost not in excess of $750,000. The work is of such a nature and magnitude that it cannot be accomplished by routine day-to-day facility maintenance or by related routine facility work efforts that are provided for in other than CoF estimates.

PROJECT DESCRIPTION:

Proposed rehabilitation and modification projects for FY 1987 totaling $30,000,000 are described under "PROJECT COST ESTIMATE." The total program of $30,000,000 has been distilled from requests of approximately $54,000,000 and represents only a modest request in relation to the backlog of this type of work. Based on relative urgency and expected return on investment, the projects which comprise this request are the highest priority requirements. Deferral of this mission-essential work would adversely impact the availability of critical facilities, program schedules, and energy conservation objectives. Only those projects estimated to cost less than $150,000 have not been individually described or identified by Center. The total cost of these miscellaneous projects is $680,000.

During the course of the year, some rearrangement of priorities may be necessary. This may force a change in some of the items to be accomplished. Any such change will be accomplished within available resources. The following broad categories of work are described further in the "PROJECT COST ESTIMATE:"

a. Utility Systems	5,300,000
b. Fire Detection/Protection Systems	2,475,000
c. General Purpose Buildings	3,005,000
d. Technical Buildings/Structures	17,275,000
e. Pavements and Drainage	1,945,000

A. Ames Research Center (ARC).. 1,795,000

1. Rehabilitation and Modification of High Pressure Air Distribution System................ 745,000

The high pressure air distribution system was installed over 25 years ago and serves all major Ames research facilities. During subsequent years piecemeal additions were made resulting in a system that has no central monitoring and control station and no control and monitoring devices within individual using areas. This project will provide necessary piping, valves, and control and monitoring electronics to connect four major high pressure air users to the central station. Valves and piping will be upgraded and new instrumentation and controls will be provided. This project is part of a multi-year program to modify the high pressure air system and upgrade it to a safe and reliable operating system.

2. Modifications to Various Buildings for Safety.. 430,000

This project is part of an ongoing effort to correct fire and personnel safety deficiencies in old buildings that were built using outdated safety codes or in which the use has changed significantly so that old safety code applications must be reassessed. Modifications to seven buildings will include fire resistant exit enclosures, additional fire exit doors and signs, electrically activated fire rated doors at stairwells, fire alarm pull boxes, fire dampers in existing ducts, and upgrading of some electrical work to meet hazardous area requirements. The buildings involved are N-211, N-213, N-237, N-239, N-240, N-240A, N-243, and N-244.

3. Modification of Aerodynamic Heating Facility (N238).................................... 620,000

This project will provide a new radiative heating system at the Interaction Heating Facility that will interface with the existing 60-MW ARC-jet. The combined facilities will provide radiative and convective heating necessary for simulation of high speed, high altitude flight in testing thermal protection systems. This testing will be required for the aero-assisted orbital transfer vehicle and other future hypersonic vehicles. Radiative heating will be provided by two 32 MW xenon arc lamp solar simulators with a variable flux level of 10 to 35 watts per square centimeter on a 12.7 centimeter (5 inch) diameter target. The project includes necessary power, control, cooling, and optical support equipment.

B. Dryden Flight Research Facility (DFRF).. 1,195,000

1. Rehabilitation and Modification of Communications Ducts................................ 460,000

Existing communications ducts require rehabilitation because of deterioration caused by flooding, water seepage, and cave-ins. Most ducts are damaged or full of cables and cannot accept new cable runs.

Communications cabling is required for new programs and facilities. With the existing ducts in the present state of disrepair, new cable runs would require costly new duct banks to be installed. This project will modify, replace, or upgrade communications ducts between buildings, and where practical, consolidate cables in existing ducts. This will free space for future cable at a much lower cost than installing new duct banks.

2. Modifications for Aeronautical Test Range Security.................................... 735,000

Present and future flight test programs require processing classified data and securing classified documents. At present, the Dryden Western Aeronautical Tracking Range data processing equipment and procedures fail to meet classified criteria for either physical or electronic security. This project will allow NASA to meet minimum security criteria for the computer area used to process test range data. It is necessary for NASA to access this classified data so that technical information can be transferred for NASA research. The security improvements will include, but not be limited to, red/black power cable separation and filtration, computer access intrusion alarm system, physical security of door, window, and other perimeter penetrations, and improved grounding.

C. Goddard Space Flight Center (GSFC).. 2,110,000

1. Modification of Smoke Detection System in Data Interpretation Building.................. 490,000

This project provides for the replacement of the 20-year old, obsolete smoke detection system for Building 23. Work will include the replacement of the non-zoned smoke detection system with a zoned annunciation system, including new smoke detector heads and new signal wiring. The new system will guide fire fighters to the location of a fire within the building. This new system is essential to upgrade the level of fire protection in this building to within present code standards.

2. Modification of Optical Facilities in the Instrument Construction and Installation Laboratory.. 400,000

This project provides for the modification and expansion of the optical facilities in the Instrument Construction and Installation Laboratory, Building 5, to accommodate fabrication and testing of up to 200 optical system components per year. Work will include enlargement of the Optical Grinding Laboratory to house two new grinding machines, support modification of controls for existing machines and improve facility safety. In addition, a high bay area will be converted to an Optical Micro Finishing Laboratory to house new sophisticated optical fabricating and testing equipment, relocated and modified optical polishing equipment, mechanical and electrical support space and storage. Additional space will be modified to provide a staging and technical support area for the remainder of the laboratory. This project is necessary to provide for increases in the GSFC optical manufacturing capability in support of a growing number of Shuttle borne instruments such as SPARTAN experiments and advanced optical systems for free fliers in the explorer series.

3. Modifications for Laser Inter-Satellite Communications Facility in the Frequency Standard and Test Facility.. 200,000

This project provides for conversion of the Laser Ranging Facility into a conventional class 10,000 clean room with temperature and humidity control, and two small building additions to house a change room and mechanical and electrical support equipment. These facility modifications are required to permit the installation of two multi-axis test tables which simulate spacecraft dynamics. These test tables are essential to "full-up" systems level tests of laser inter-satellite communication systems. They will permit testing/evaluating data acquisition, tracking and pointing of communications systems. The facility and equipment modifications are necessary to support Space Station and free flyer programs.

4. Modification of Uninterruptible Power Supply (UPS) System in the Administrative Support Building.. 350,000

The Computer Services Branch (CSB) provides payroll, NASA Equipment Management System (NEMS), and accounting support for the Center. Due to continual growth of the centerwide administrative automated data processing operations, only a limited amount of the essential electronic equipment is protected by the existing UPS. An upgraded system is required to provide comprehensive back-up. This project will provide a 150 KVA UPS System, additional wiring and ventilation system to support the CSB computers, construction of an addition to house the new UPS, and the installation of additional cooling capacity for the projected increase in automated data processing equipment (ADPE). The proposed UPS room addition will also solve the long standing noise problem caused by the existing UPS being located in the core of the building.

5. Rehabilitate Thermal Test Chambers in the Payload Testing Facility..................... 385,000

This project provides for the replacement of thermal shrouds and thermal control systems in two thermal-vacuum facilities. Work includes the removal of the cryogenic thermal shrouds and thermal control systems from two 3 feet in diameter by 3 feet in length thermal-vacuum test chambers and installation of new cryogenic thermal shrouds and new thermal control systems. These chambers are "workhorses" used for testing subsystems in the development and qualification of instruments as flight hardware. The thermal shrouds in both facilities are made of copper and during the 20 plus years of use have accumulated over 1,200 thermal cycles which has caused increased fatigue cracks and shroud leaks. These cracks and leaks cause freon to come in contact with experiments being tested in the chamber. Experiments such as GRO/EGRET cannot tolerate exposure to this compound. It is therefore necessary to correct this situation and improve the operation of these chambers.

6. Rehabilitation and Modification of the Central Heating and Refrigeration Plant.......... 285,000

This project provides for the rehabilitation of the architectural, electrical and mechanical systems in Building 24. The work includes the replacement of five end-of-life boiler stacks, refurbishment of one and installation of two sound proof control booths, increasing the load bearing capacity of the steel plate floor in the south chiller room, improving access to the emergency generation room, repair of the bridge crane controls, and miscellaneous required repairs and modifications to the building exterior and other minor systems. The proposed work is required to improve the health and safety conditions in and around the plant and to restore the overall operating efficiency of the aging plant.

D. Jet Propulsion Laboratory (JPL).. 2,070,000

1. Modifications for Chemical Research and Instrument Analysis Laboratory.................. 740,000

This project provides for the modifications to the seventh floor of the Physical Sciences Laboratory, Building 183, to house a 7,000-square foot chemical research and instrument analysis laboratory. The existing chemistry facilities are located in three very old and obsolete buildings which are substandard, overcrowded, unsafe, and scheduled for demolition in the near future. The new laboratory will be used to conduct chemistry research, accommodate analytical instrumentation, and provide safe laboratory space. The laboratory is necessary for research in such areas as lithium batteries, alkali metal thermoelectric conversion, molecular electronic processes and advanced dielectric materials. The work will include fume and/or horizontal air flow exhaust hoods, wet sinks, precise temperature controlled laboratories, and ventilated storage areas for flammable chemicals. Safety equipment will include emergency showers and eye fountains. Natural gas, water, compressed air, vacuum and gaseous nitrogen supplies will be installed.

2. Modification for Pneumatics, Clean Assembly and Test Laboratories...................... 285,000

This project provides for the modification of 5,280 square feet of Building 233 to support the development assembly and testing of various pneumatic valves and controls. Currently this function is performed in Building 113 which is scheduled for demolition in 1987. The southeast quadrant of the first floor of Building 233 will be renovated to support the required testing equipment, and an existing clean room will be modified as required. Building 113 was originally constructed 35 years ago and has become crowded, inefficient and very costly to maintain. The present pneumatic shop conducts high pressure test operations behind barricades located under a corugated metal roof. The clean room portion of Building 113 is over 233 years old and the poor design makes it inadequate for the present use. Moving this function to Building 233 will correct the crowded, unsafe and inadequate conditions that are prevalent in the existing shop area.

3. Modify Pioneer, Surveyor and Corporal Roads... 700,000

This project will modify Pioneer, Surveyor and Corporal Roads by realignment, construction to proper widths, and reduction of existing grades. Also included will be installation of street lights, retaining walls, and landscaping; as well as the demolition of a small 30 year old building (53), and relocation of a small heating plant. These roads are main vehicular arteries in the north lab area of JPL. The easterly 1,240-linear foot portion of Pioneer Road is difficult to traverse due to sharp turns, abrupt steep grades, and a 12-foot wide constriction near Building 148. The existing paving is cracked and overdue for replacement. The 400-linear foot segment of Surveyor Road is also in a poor state of repair, has a sharp 180° curve combined with a steep grade which renders this stretch of road very difficult and unsafe to negotiate. A 400-linear foot stretch of Corporal Road has a hazardous hairpin bend around Building 188. This project will correct these unsafe conditions and provide proper access to the north areas of the Laboratory.

4. Modification of Heating, Ventilation and Air-Conditioning System....................... 345,000

This project provides for the modification of the existing mechanical system serving the high-bay clean room in the Environmental Laboratory, Building 144, to provide precise humidity control. This clean room is used to perform vibration tests on flight hardware, primarily large subsystems and spacecraft. It is currently being used to test the Galileo flight spacecraft. Typical humidity requirements for flight programs range from a maximum of 55 percent to a minimum of 25 percent relative humidity. Recently, local ambient conditions have caused the humidity to exceed 70 percent in this clean room. Presently there is no effective means to reduce the relative humidity to within acceptable levels. As a result, spacecraft such as Galileo have to be "bagged" and put under a purge system. This laboratory will continue to be used for future programs and a precise humidity control system is essential.

E. Johnson Space Center (JSC)... 3,865,000

1. Modification of Shuttle Mission Simulator Complex...................................... 550,000

This project provides for modifying approximately 3,100 square feet of space in Building 35 of the Shuttle Mission Simulator Complex to accommodate a new replacement computer system. The existing system is obsolete and increasingly unreliable. This system supports software development and simulator interface testing. Work includes providing necessary computer flooring, fire detection, air-conditioning and electrical systems.

2. Modification for Advance Avionics Systems Development.................................. 700,000

This project is necessary to modify and rearrange several areas in the Shuttle Avionics Building (16) to accommodate the installation of new computer systems, engineering simulator and test equipment in support of the data management system, and advanced avionics systems development for Space Station applications. A mainframe computer will be installed in room 2012 to support software development, analysis, and interfaces for data management, displays, and controls systems. Room 1040 will be modified to establish a software support environment and test bed for the design and testing of displays and controls subsystems, the data communications system, and for overall Space Station systems engineering simulation. Work includes reconfiguring space and utilities, providing raised flooring, air-conditioning, electrical power, fire protection and other work associated with computer and data communication systems.

3. Rehabilitation of Anechoic Chamber... 725,000

This facility is required for critical antenna testing in support of Shuttle sustaining engineering and Space Station communication test bed. The microwave absorber material in this chamber has been in use for 20 years and has suffered physical damage and deterioration to the point where testing is impaired. This project will replace approximately 18,400 square feet of the microwave absorber material. Replacement material will provide a higher degree of microwave absorption and will have a much higher fire retardant level than the existing material.

4. Modifications of Research and Engineering Data Processing Areas........................ 700,000

This project provides facility modifications necessary for the installation of new computer equipment associated with build-up of the Engineering Computational Complex, in Buildings 16 and 17 and a data cable interconnection between these two data processing areas. The new research and engineering computing systems are necessary to support Shuttle sustaining engineering and Space Station engineering, system development and integration testing. Work in Building 16, includes providing approximately 270 feet of 1-hour rated firewalls, establishment of a 320 square foot computer tape library and the normal air-conditioning and electrical power associated with the computer installation. In Building 17, approximately 175 square feet of computer flooring will be provided along with necessary air-conditioning and electrical power to accommodate the new computer equipment.

5. Rehabilitation of Aircraft Operations Facilities, Ellington Field...................... 500,000

This project provides for general rehabilitation to the main hanger complex that services NASA's aircraft such as the T-38's and Shuttle training aircraft. These facilities were constructed in 1942 for the Army and have been in continuous use with only minimal maintenance and upgrading since that time. Work will include general renovation to the siding, hangar door rails, windows and doors, replacement of air-conditioning units and replacement of approximately 1,000 square yards of concrete aircraft mooring apron.

6. Modification of Photographic Waste Collection System................................. 690,000

This project provides extensive modifications to the photographic waste collection system located in buildings 8 and 8a to comply with federal regulations on underground hazardous waste tanks. The existing photographic waste collection system consisting of underground waste lines and underground concrete waste holding tanks must be replaced with above ground tanks to assure leak prevention/detection in accordance with hazardous waste regulations. Rerouting of the chemical waste lines, installation of waste transfer pumps and alarms and augmentation of the ventilation and exhaust system will also be provided.

F. Kennedy Space Center (KSC)... 3,035,000

1. Rehabilitate Utility Annex Chiller.. 415,000

This project provides for the complete overhaul of refrigeration Unit 4 at the LC-39 Utility Annex. This unit provides air-conditioning to program critical facilities such as the VAB and OPF. The work includes rehabilitation of the 2790 HP motors, motor control center and exciter, cleaning gearboxes and heat exchangers, retubing of evaporators, compressor overhaul, and updating of the control panel. This project completes the overhaul of the LC-39 Utility Annex chillers which have been in continuous service since 1967.

2. Rehabilitate Pad A Switch Station... 200,000

This project will refurbish Switch Station 902 (Pad A) which houses the 20-year old switch gear and transformers which have deteriorated due to the saline and launch environment. A washdown system will also be installed to protect the new equipment from the effects of corrosive combustion by-products released during launch by the STS vehicle.

3. Modify VPF Cooling Tower Capacity.. 180,000

This project provides for the construction of a 400-ton ceramic cooling tower and installation of two 1,200 GPM condenser water pumps at the Vertical Processing Facility (VPF) to replace the existing cooling tower and condenser waterpumps. The cooling tower facilities provide a temperature-controlled environment for processing flight hardware, and are 20 years old. Originally, the equipment supported a lighter load but now must support higher heat loads necessitating a larger cooling tower.

4. Modify Air Compressors in Utility Annex... 430,000

This project provides for the replacement of the two existing 350 HP air compressors at the Utility Annex with four state-of-the-art 100 HP compressors. These units will have a common progressive start/load-up system for efficiency. The existing compressors are 20 years old and spare parts are difficult and expensive to obtain. The compressed air is used to support pneumatic tools, equipment and many other systems in the OPF and VAB.

5. Modify Four Air Compressors in O&C Building.. 265,000

This project provides for the replacement in kind of four obsolete 40 HP air compressors and installation of two 60 HP air compressors. The new compressors are state-of-the-art and energy efficient with increased capacity. The existing compressors are worn and have been repeatedly rebuilt. They have passed the point of economical repair and maintenance costs are excessive.

6. Modify Scape Facility Access Road to Pad A... 645,000

This project will upgrade the road base and pave the existing dirt road between Pad A and the Self-Contained Atmospheric Protective Ensemble (SCAPE) Facility. It will also provide site development and expand utilities for the SCAPE Facility box cars/trailers. The new road will provide equal distance access to Pads A&B from the centrally located SCAPE Facility, thereby equalizing the "stay times" (time that emergency crews can stay at the pad) for SCAPE crew operations at both Pads. Equal "stay times" will eliminate the hazards and confusion of having different operational safety procedures for Pads A&B.

7. Modify Fire Protection System in Propellant Lab and High Pressure
Gas Maintenance Facility.. 155,000

This project provides an automatic fire sprinkler water deluge system with fire cutoffs, and smoke and heat venting. Draft curtains will be installed throughout the Propellant Lab High Pressure Gas Maintenance

Facility. An automatic fire suppression system is required for the hazardous materials handled, such as propellant samples. Due to the numerous partitioned areas, it is very difficult for occupants to exit the facility quickly. The partitions also hamper fire fighting. The fire suppression system will provide the necessary protection for both personnel and the facility in the event of a fire.

8. Modifications for Life Science Support Facility.. 745,000

This project provides for the modification of approximately 5,000 square feet of space adjacent to the existing Life Science Support Facility (LSSF) located in Hangar L, CCAFS. The modifications will provide a 2,000 square foot experiment/hardware mock-up and staging area, a 600 square foot bonded storage area, a 400 square foot electro/mechanical shop, two 400 square foot laboratory storage areas, and two large primate holding rooms of 250 square feet each. The additional space is needed to accommodate rapidly increasing life sciences experiment processing requirements. An experiment/hardware mock-up and staging area is needed to facilitate flight hardware turn around/processing between missions. A bonded storage area is needed for initial storage of experiment hardware between arrival at KSC and commencement of processing/integration with flight systems, and for storage of flight certified hardware to preclude the requirement of recertification. An electro-mechanical shop is essential for support of pre and post flight experiment processing and trouble shooting.

G. Langley Research Center (LaRC)... 2,895,000

1. Rehabilitation of HVAC System, Computer Complex.. 745,000

This project provides for the partial rehabilitation of heating, ventilating, and air-conditioning systems serving LaRC's scientific computer complex. Work includes installation of free-standing air handling units in each computer room and supporting modifications to the utility systems. The air handlers and air distribution systems serving corridors and perimeter offices will also be upgraded. The computer complex requires uninterrupted control of temperature and humidity. Replacement of the large central air handlers with free-standing smaller computer room units will provide a higher degree of reliability and more flexibility in matching cooling capability to computer loads. The existing central air handling units are 25 years old, unreliable, and difficult to maintain.

2. Modifications for Integrated Problem Solving Laboratory................................ 250,000

This project modifies Building 1229 for an Integrated Problem Solving Laboratory of approximately 4,000 square feet for the installation of various computer and display equipment. The modifications will include: relocating existing windows, replacing exterior doors, installing a suspended ceiling with flush mounted light fixtures, a computer deck floor, a new HVAC system, and upgrading the electrical distribution system. The area will provide space to house equipment used by research teams from government, universities and industry to investigate new ways to automate design decisions, to integrate design disciplines into unified systems, and to manage, evaluate, and store the exploding volume of design data.

3. Modifications for Advanced Technology Research Laboratory.............................. 530,000

This project provides for the construction of a 3,500 square foot addition to Building 1200, and modification of the second floor and capacitor room of the existing building for gas laser research. Modification of the second floor will provide approximately 2,400 square feet of office space, and the existing capacitor room will provide approximately 3,000 square feet of environmentally controlled space. A potential breakthrough in space transportation and power transmission may be possible with a high powered, high-efficiency laser in earth orbit. The most promising candidate for such an application is the solar-pumped gas laser prototype developed by LaRC and demonstrated in October 1980. This research, now being conducted in the High Speed Aerodynamics Facility, is impeded by the operation of six wind tunnels which cause excessive vibration, humidity, dust, and temperature fluctuation in the laser test area. This project will provide the proper environment necessary for continued gas laser research.

4. Rehabilitation of Materials Processing and Developments Shop........................... 420,000

This project provides for the rehabilitation of 12,800 square feet of shop, office and restroom areas in Building 1267A. The rehabilitation will include: the installation of insulated windows; roof replacement; HVAC upgrades; painting; conversion of restrooms with lockers and showers; and a 950-square foot addition to provide space that will include a conference room. Building 1267A houses LaRC's Materials Processing and Development Shop. The building is 24 years old and has never been rehabilitated. The facility is used to develop and test high-tech materials and related manufacturing techniques, which are essential on-going programs. The proposed rehabilitation is necessary because age and extensive use has resulted in the gradual deterioration of the facility which can no longer be corrected by routine maintenance. Installation of new windows and insulated roofing also will increase energy efficiency.

5. Rehabilitation of Research Aircraft Operations Building................................ 455,000

This project provides for the rehabilitation of approximately 62,000 square feet of office and laboratory space in Building 1244. The work includes: installing suspended ceilings with recessed light fixtures; new energy efficient windows; upgrading restrooms; painting interior walls; installing raised deck flooring; adding acoustical treatment; and installing a new fire protection system in the Experimental Avionics Integration Laboratory. The research aircraft operations building provides office and laboratory space for approximately 300 research and operations personnel. This facility has not been upgraded since its construction in 1951. The deteriorated condition of this facility is such that normal maintenance is no longer cost effective.

6. Rehabilitation of CF_4 Tunnel... 495,000

This project provides for the rehabilitation of approximately 15,000 square feet of laboratory space in the CF_4 Tunnel Facility in the Hypersonic Propulsion Test Area. The work includes modifications to an existing bridge crane, the rehabilitation of the vacuum pumping system, exterior walls, windows, roof, restroom facilities, interior walls, floor, ceiling, and improvement of the lighting and HVAC systems. The existing facility has had no significant modification or rehabilitation since original construction during 1960. The facility has seriously deteriorated and rehabilitation is necessary to restore building integrity.

H. Lewis Research Center (LeRC)... 2,970,000

1. Modification to Electrical Systems, Material and Structures Building.................. 400,000

This project provides for modifications to the electric power feeds and distribution systems in the Material and Structures Building (49). The work includes modification of the 2,400 volt systems; replacement of the existing transformer to increase system capacity; installations of a new 480-volt distribution switch board and redistribution of existing 208 volt loads to provide additional capacity for expansion. The present 480-volt and 208-volt systems are fully loaded. This project is needed to accommodate the increased electrical requirements to effectively support current and future research activities in this facility.

2. Modifications for Class 100 Clean Room, Model Preparation Building..................... 610,000

This project provides for modifications to approximately 1,000 square feet on the first floor of the Model Preparation Building (55) and the construction of approximately 200 square feet of new mezzanine area. The work includes the installation of a modular wall system, a 12-inch raised floor system, a laminar flow air system, a modular ceiling system and a 500 KVA transformer to replace the existing 300 KVA transformer. This project will provide a class 100 clean room to be used to develop materials, processes and component structures for use in the development of microwave integrated circuits to support advanced space communications requirements.

3. Modification of Tank 5, Engine Propulsion Laboratory.................................. 695,000

This project provides for modifications to the space environment simulation facility, vacuum tank 5 in the Electric Propulsion Laboratory (301). The work includes installation of pumps, controls, and inert gas supply system, modifications to the existing liquid nitrogen and the cryogenic helium systems. This project will upgrade the facility space simulation capabilities and improve the operating conditions. These modifications are required to enable the facility to support the electric thruster engine research program.

4. Rehabilitation of Offices and Warehouses... 650,000

This project provides for the rehabilitation of the offices and warehouse area on the east side of Building 21. The work includes replacement of the undersized air-conditioning system; upgrading of the lighting and electrical service systems; installation of four loading docks; rehabilitation of walls and ceilings; installations of insulation and other miscellaneous architectural work. Portions of this building were constructed in 1944. Normal maintenance can no longer effectively keep the building in efficient operation. This rehabilitation work is required to correct deteriorated conditions and improve the efficiency of the warehouse operations. The existing plumbing and mechanical systems are very old and require frequent maintenance. These modifications will also greatly improve the overall thermal efficiency of this portion of Building 21 and will effectively reduce energy consumption costs.

5. Modifications to Propulsion Systems Laboratory... 615,000

This project provides for modifications of the heater and turbo expander piping in Building 125 to allow transient range testing of engine systems. The work includes installations of four (4) electro-hydraulic valves; an added hydraulic system; one (1) exhaust muffler, piping modifications, control modifications and associated mechanical/electrical work. The combustion air supply system provides steady state test conditions with engine transients limited to rotational speed changes at a constant MACH number and altitude. These modifications will provide additional throttle valves and vents to allow transient numbers and altitude testing capability. Most engine system problems occur during transient operation.

I. Marshall Space Flight Center (MSFC).. 3,840,000

1. Modifications of High Bay Assembly Facility.. 740,000

This project provides for modifications of the High Bay Assembly facility for Space Station Common Module Support Systems Integration. Work includes installation of the module docking adapter and enlarging the class 100,000 clean room by approximately 500 square feet. A two-ton overhead crane will also be installed. An automated control system with a 250 KVA Emergency power supply system will be installed and connected to the various test control areas. Included are modifications to the simulators, environmental control, lighting, and electrical systems and the hazardous test area in Building 4620. This work is required to conduct subsystem and integrated system tests of life support equipment for Space Station.

2. Modification for Uninterruptible Power Supply in Laboratory and Office.................. 545,000

This project provides for modifications to the Laboratory and Office Building 4487 A-Wing for the installation of a 400 KVA uninterruptible power system (UPS). The UPS will include static rectifiers and invertifiers, lead-calcium batteries for 10-minute operations, and related electrical and mechanical systems The UPS is required to provide a reliable source of electrical power to support SSME simulation systems. These systems are extremely sensitive to electrical power disturbances and a reliable source is required to prevent loss of data that would severely impact real time SSME flight hardware and software integration, engine test anomaly investigations, and launch support activities.

3. Modifications for Common Module Power Distribution System Test Facility................. 250,000

This project will modify approximately 12,000 square feet of space in Building 4475 to install a computer to support the Space Station common module power distribution system. Facility modifications include the replacement of walls, ceilings, installation of computer flooring, electrical power distribution, HVAC, fire protection, and related work. MSFC is responsible for the Space Station power distribution and management within the common module, and the modifications to Building 4475 are essential to provide space for the development, testing and definition of the common module power distribution system.

4. Modifications for Space Station One-G Simulator.. 365,000

This project provides for modification to support Space Station one-G simulation activities. The work includes partitions, raised floors, HVAC, compressed air for air bearings and electrical power for simulation equipment. Also included is related work for a workshop, observation platform and office space. These modifications are required to support the structural design and development of the Space Station. Without this facility, MSFC will not be able to meet commitments and schedules for the structural development and interface activities needed to support the Space Station program.

5. Rehabilitation of Surface Treatment Facility... 670,000

This project provides for rehabilitation of the Surface Treatment Facility, Building 4760. Work includes the replacement of deteriorated liners in eight surface treatment tanks and foundations in six tanks, pumps and piping. Also included is the installation of a 16-foot high by 20-foot wide insulated steel door, painting, modification to the HVAC and electrical power systems, and related work. Building 4760 provides surface treatment capability for metals used in various programs. Due to the corrosive nature of the environment, the building and industrial equipment have deteriorated significantly and emergency repairs are difficult. A delay in this rehabilitation work will result in a loss of capability provided by the facility with a significant impact on the support of programs such as Space Lab and Payloads, Space Telescope, and Shuttle.

6. Modification of Environmental Effects Facility.. 740,000

This project provides for modifications to 4,000 square feet of space in the Non-Destructive Evaluation Laboratory, Building 4605 for an environmental effects facility. Modifications include the installation of partitions, ceilings, 800 square feet of raised flooring for the instrumentation laboratory, office space, an electrical substation, emergency power and other related work. Four test cells will be provided with leadwall shielding, inert gas system, television and radiation monitoring. These modifications are required to evaluate Space Station materials with respect to long-term exposure to the space environment. The facility will provide the capability for simulated long-term space environment effects testing for the development of stable, long-life materials for Space Station application.

7. Modifications for Productivity Enhancement Laboratories.................................. 530,000

This project provides for modifications of 7,400 square feet of space in Building 4707 for productivity enhancement laboratories. Work includes the installation of partitions, ceilings, 500 square feet of raised flooring, lighting, and electrical power. Also included is a HVAC system to control the temperature and relative humidity, utilities, and high purity shop air. These modifications are required to provide a facility for the development of productivity enhancement techniques that will reduce the cost of space vehicles. These techniques will include the development of lightweight, high strength materials, improved manufacturing processes, advanced robotic development, and improved insulation, and data processing.

J. Michoud Assembly Facility (MAF).. 2,010,000

1. Rehabilate the Columns, East Side Main Manufacturing Building.......................... 640,000

This project strengthens the ceiling support columns in the Main Manufacturing Building. Recent studies indicate that during high wind conditions, a significant number of columns in the Main Manufacturing Building (103) are overstressed according to contemporary structural design standards. The studies indicate that Building 103 is "safe" below 80 mph winds; however, the American National Standards Institute (ANSI) code requires a 100 mph design standard. This project will upgrade the remaining column system to these standards. Work includes installing steel cover plates on columns and cross bracing in several locations. Rerouting of utilities and other structural modifications will also be accomplished. Work will be phased to cause minimal impact to on-going External Tank (ET) production activities.

2. Modifications to East Master Substation.. 535,000

This project is necessary to eliminate a potential single point failure in the electrical power distribution system at MAF. Electrical power is received via two (East and West) on-site master substations. The West Master substation has one 20-MVA transformer with one incoming feeder circuit. The East Master substation has two 20-MVA transformers but only one incoming feeder circuit. Should either of the existing incoming feeder circuits fail, MAF electrical capacity would be reduced by one-half. To improve this situation, a second, parallel incoming feeder circuit with associated switch gear and circuit breaker will be provided to the East Master substation.

3. Rehabilitation of Drainage System... 600,000

During heavy rain storms, the Main Manufacturing Building (103) floods, causing equipment damages and production shut down. The drainage system for the roof of Building 103 (43 acres of surface) runs down interior drain lines located inside the building to under slab pipes, which in turn drain into the East borrow pit. This pit connects to the South borrow pit. Flooding is caused by rapid rise of water in the borrow pits which causes a back flow in the drainage system. To prevent flooding in Building 103, a detention weir will be provided in the South pit upstream of the pump station. This will detain water from entering the East pit and allow the pump station to maintain a lower elevation in the East pit and keep up with the flow. This project will also provide repairs to the underground storm drain lines in Building 103.

4. Rehabilitation of Clean Room.. 235,000

This project provides for the rehabilitation of the vacuum system, trichloroethylene degreaser and overhead handling system in the clean room located in the Main Manufacturing Building (103). The clean room area is used for cleaning and assembly of External Tank components typically requiring LO_2 compatibility, such as internal wire harness, lines and other hardware. The room's environmental systems are over 20 years old and need general rehabilitation. The vacuum system components, motors, fans and filters are mechanically deteriorated and require replacement. The trichloroethylene degreaser needs rework for proper ventilation of vapors. The overhead component handling system must be extended into two rooms for efficient movement of heavy components through the cleaning process and to prevent safety problems associated with manual lifting.

K. National Space Technology Laboratories (NSTL).. 1,440,000

1. Rehabilitation to Fluid Component Processing Facility................................ 700,000

This project is necessary to improve the work flow, safety, and productivity of the Fluid Component Processing Facility, Building 2205. This facility provides repair, cleaning and testing services to high pressure gas and cryogenic system components for the Space Shuttle Main Engine (SSME) test facilities. Pneumatic testing of these components is conducted in open test cells located adjacent to Building 2205 and is exposed to wind, humidity, dirt, and rain. All test articles must be transported across an open air corridor (outside) for pneumatic testing in these cells. The service shop is operated 16 hours a day and has a work backlog of approximately 9,000 man-hours. It is further anticipated that service demands will increase by 50 to 60 percent in the near future to support the projected expansion of the SSME testing program. This project provides for enclosing the open air corridor and the existing test cells, remodeling the components service shop clean room area to provide direct access to test cells and a 3,000-square foot addition to accommodate reconfiguration of the existing processing area. Necessary temperature, humidity and contamination controls will also be provided.

2. Rehabilitation of High Temperature Hot Water Generation System......................... 740,000

This project is required to improve the operating efficiency of the High Temperature Hot Water (HTHW) generation system for the Space Shuttle Main Engine (SSME) test area. The existing HTHW generators are oversized for the present load and are required to operate in an inefficient low firing rate range. This low rate of operation reduces the control span and the operating systems are no longer sensitive enough to maintain effective control. This project will correct this situation by providing a low temperature hot water system for space heating and reheating facilities within the SSME test area. The work will include the installation of a new boiler in the Test Control Center, Building 4110, the pumps necessary to move the hot water through 2,200 linear feet of new insulated supply and return lines to test stand A-1 and 3,100 linear feet of additional new piping and pumps to the test stand A-2. This project will also provide for all necessary ancillary equipment for the safe and efficient operations of the system.

L. Wallops Flight Facility (WFF).. 1,430,000

1. Rehabilitate and Modify Second and Third Floors, Management Education Center........... 730,000

This project provides for the rehabilitation of the second and third floors of Building E-104 (14,000 square feet). The work includes installation of partitions and interior finishes to provide conference, classroom and office space, installation of toilet facilities, extension of the mechanical and electrical systems to the second and third floors, modifications to the building ventilation system, and installation of an elevator. This work is necessary to provide the additional conference, classroom and support office space required by the NASA Management Education Center and for management and technical conferences, seminars, and retreats. The elevator will provide handicapped personnel access to the second and third floors.

2. Rehabilitate and Modify Boiler Plant..	300,000

This project provides for the rehabilitation and modification of the Wallops Flight Facility main boiler plant, Building D-8. The project includes upgrading three unreliable 650 horsepower, 25,000-pound per hour boilers and the rehabilitation and modification of deteriorated 20-year old boiler plant piping, valving, and controls. The work is required for the continued safe and efficient operation of the main boiler plant. Deteriorated piping must be replaced and controls must be upgraded for increased reliability and energy efficiency. The three existing main boilers are 20 years old and require replacement and repair of tubes, cleaning, and the upgrading of burners for increased efficiency and improved reliability.

3. Rehabilitate Transmitter Facility..	220,000

This project provides for the replacement of single pane windows and doors with thermal products; the sealing and repair of the concrete deck roof; the replacement of flashing; the sealing and painting of interior walls; and the installation of a sprinkler system throughout the building. This transmitter facility is a valuable asset to NASA that houses the command and destruct equipment and systems for WFF launches. It is also used for communications with the Space Shuttle program. The the 20 year old facility requires this work to arrest accelerating deterioration and reduce the risk of damage to key communications equipment.

4. Modify Technical Service Shop (F-10) Entrances......................................	180,000

Building F-10 was constructed as an aircraft hangar in 1954 but has since been converted to a machine shop with associated support office space. The large hangar doors are repeatedly opened during the day to allow for the movement of equipment and supplies in and out of the building. The opening created by these hangar doors is much larger than is required to move the equipment. This results in an excessive loss of conditioned air from within the hangar every time the doors are open. Significant energy is lost and the working conditions in the building become uncomfortable. Of equal concern is the personnel egress from the north and south wing floor office space which is via exterior stairways exposed to the weather. These stairs become wet during rain, and collect ice and snow during the winter. This project will install an insulated curtain wall and a smaller-sized roll up door in the opening which presently contains the hangar doors. The second floor office entrance stairways will be enclosed to provide safe entrance and exit during inclement weather.

VARIOUS LOCATIONS	665,000
1. Modifications for Fire Protection, Canberra, Australia	665,000

This project modifies the deteriorated and obsolete fire protection equipment throughout the Canberra Deep Space Communications Complex for improved fire protection. The work includes the installation of electric and diesel driven fire pumps, and a 180,000 gallon water storage tank and associated piping. Also included is the replacement of obsolete fire detectors and installation of a central monitoring system to identify the location of a fire. A Halon fire suppression system will be installed in the equipment chambers of the DSS-42 and DSS-43 antennas. The present water supply system lacks the required pressure, flow capacity, and supply necessary for emergency fire suppression system throughout the complex. The detection system is unreliable, and lacks a central alarm panel system to alert operations personnel to the location of the fire. This project will bring the fire protection system up to minimum standards for assuring an adequate fire safety posture.

MISCELLANEOUS PROJECTS LESS THAN $150,000 EACH	680,000
TOTAL	30,000,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

An estimated $30,000,000 to 35,000,000 per year will be required for continuing rehabilitation and modification needs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

SUMMARY

MINOR CONSTRUCTION

Summary of Project Amounts by Location:	Amount	Page No.
Ames Research Center	495,000	CF 12-2
Goddard Space Flight Center	840,000	CF 12-3
Jet Propulsion Laboratory	480,000	CF 12-3
Johnson Space Center	450,000	CF 12-4
Kennedy Space Center	1,220,000	CF 12-4
Langley Research Center	645,000	CF 12-5
Lewis Research Center	485,000	CF 12-5
National Space Technology Laboratories	820,000	CF 12-6
Wallops Flight Facility	695,000	CF 12-6
Various Locations	870,000	CF 12-7
Total	7,000,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE:	Minor Construction of New Facilities and Additions to Existing Facilities, Not in Excess of $500,000 Per Project
INSTALLATION:	Various Locations
	FY 1987 CoF ESTIMATE: $7,000,000
FY 1985: $5,000,000	FY 1986: $6,000,000

COGNIZANT INSTALLATIONS/LOCATIONS OF PROJECT: Various Locations

COGNIZANT HEADQUARTERS OFFICE: Office of Management

SUMMARY PURPOSE AND SCOPE:

These resources will provide for minor facility construction at NASA field installations and Government-owned industrial plants supporting NASA activities. Each project included in this program is estimated to cost not more than $500,000 and involves either the construction of new facilities or additions to facilities. The FY 1987 request of $7,000,000 will improve the usefulness of NASA's physical plant by changing the utilization of or augmenting the capabilities of various facilities. Included in this request are those programmatic and institutional projects that are essential to the accomplishment of mission objectives.

PROJECT JUSTIFICATION:

The configuration of NASA's physical plant necessarily must respond to changes in utilization and adaptations required by changes in technology or in mission needs. Demands are generated by research, development, test, and similar activities. Specific justification for each minor construction project is provided under "PROJECT COST ESTIMATE."

PROJECT DESCRIPTION:

Included in the FY 1987 minor construction program are those facility projects for institutional or technical facility needs which could be fully identified at the time of submission of this budget estimate. Items of work totalling $7,000,000 are included in this resource request and have been distilled from a list totalling over $16,000,000. Projects were selected on the basis of the relative urgency of each item and the expected return on the investment. During the course of the year, rearrangement of priorities may require changes in some of the items to be accomplished. Such changes will be accommodated within the resources allocated.

These projects represent requirements that must be met in this time frame to support institutional needs and programmatic objectives. The following listing summarizes the cost distribution by category of work:

a. General Purpose Buildings	1,320,000
b. Technical Buildings/Structures	5,200,000
c. Pavements	480,000

PROJECT COST ESTIMATE:

A. Ames Research Center (ARC)	495,000
1. Construction of Visual Display Laboratory (N-243)	495,000

Existing high bay space shall be reconstructed to provide two new floors of approximately 8,600 square feet, and adjacent space of approximately 5,600 square feet shall be modified to provide space required for a new Computer-Generated Imagery (CGI) systems laboratory. Basically two existing outdated Visual Flight Attachments (VFA's) are being replaced by new state-of-the-art CGI systems, and consolidation of other visual simulator laboratories are being relocated to consolidate functions for enhanced productivity. Without these modifications adequate floor space will not be available to support the enhanced integrated visual simulation programs now planned. Existing widely dispersed visual simulator laboratories will be consolidated into a single advanced imagery laboratory complex with supporting shop and office space. Modifications include structural and architectural, mechanical and electrical as required including independent HVAC systems with temperature and humidity control to support both new laboratory and computer areas.

B. Goddard Space Flight Center (GSFC).. 840,000

1. Construction of an Addition to the Instrument Construction and Installation Laboratory.. 490,000

This project provides for the construction of a 2,750-square foot addition to the north side of the Instrument Construction and Installation Laboratory, Building 5, housing the Diffraction Grating Evaluation Facility (DGEF). This facility will evaluate diffracting gratings, (etched glass plate used as a prism) required for long range advanced astronomy and solar physics programs. Gratings must be evaluated for efficiency, incident and deviation angles, and resolution and scattered light, as a function of wavelength under the same geometrical conditions as those in which they will be used. No space is presently available to house the DGEF which, in addition to a clean environment, requires the installation of a 65,500 pound granite block, mounted on special vibration isolators. Foundations specifically designed to support this block will be provided. Present facilities are inadequate for efficient measurement of the variety of gratings required. This facility will have the capability to simulate all geometric configurations and greatly improve the accuracy, efficiency and effectiveness of this essential class of component testing.

2. Construction of Addition to the Plant Operations Building (4)........................... 350,000

This project provides for the construction of a 1,650-gross square foot addition to Building 4 which will include 1,300 square feet of laboratory space and 300 square feet for office/support space. The facility will include an ammonia detection and exhaust system, air-conditioning, utilities, and a fire detection and protection system. This facility is required to provide adequate space and utility services to operate the Space Station Instrument Thermal Test Bed and its ancillary equipment. The facility will provide contractors and users a laboratory in which to test and evaluate Space Station heat transfer systems and devices.

C. Jet Propulsion Laboratory (JPL).. 480,000

1. Construction of North Lab Parking Areas... 480,000

This project provides for the construction of approximately 250 new parking spaces adjacent to Corporal Road near Surveyor Road, and between Pioneer and Explorer Roads in the North Lab Area. This project is the first phase of parking development north of Explorer Road. Six obsolete substandard buildings (54, 55, 73, 85, 130, 188) totaling 13,000 square feet will be demolished in order to permit grading to create the new parking areas. All existing on-site and off-site parking areas are already fully utilized and new areas must be developed to accommodate personnel moving on-site from leased space. Included with the paved parking area development will be associated lighting, retaining walls, stairways, and landscaping within the parking complexes.

D. Johnson Space Center (JSC) 450,000

1. Construction of Maintenance and Operations Support Facility 450,000

This project provides for the construction of a new one-story building approximately 50 feet by 100 feet, to house maintenance and operation support services personnel and related functions. These functions are currently housed in overcrowded areas in Building 327 and in temporary areas on the second floors of Buildings 325 and 329. This project will allow personnel consolidation, improve performance and efficiency, and permit better use of space in Buildings 325, 327 and 329. The new building will be prefabricated metal on a reinforced concrete slab and contain office space for 35 personnel, a communications control room, a records storage area and a mechanical equipment room. Air-conditioning, heating, plumbing and electrical systems will also be provided.

E. Kennedy Space Center (KSC) 1,220,000

1. Construct Generator Maintenance and Storage Facility 490,000

This project provides for the construction of a 5,500-square foot generator maintenance and storage facility to support the Shuttle Processing Contractor (SPC). The existing generator facilities are being used by the Base Operations Contractor (BOC) leaving the SPC inadequate space and facilities. The generator maintenance and storage facility will provide the necessary space to maintain the 111 generators and 17 pieces of miscellaneous equipment now operated by the SPC in supporting operations at KSC and landing sites remote to KSC. This facility will replace two inadequate maintenance bays presently used by the SPC.

2. Addition to Launch Equipment Shed (LES) Facility 435,000

This project will enclose and air-condition a 30-foot by 40-foot shed at the east end of the LES building, and install a 5-ton overhead crane. A new 150-foot by 30-foot shed will be constructed along the south side of the LES building. Enclosing the existing shed will improve shop efficiency and working conditions by eliminating work stoppages due to inclement weather and the new larger structure will accommodate additional equipment and the increasing workload presented by Pad B launch activity.

3. Construct Hypergolic Maintenance Facility (HMF) GSE Storage 295,000

This project provides for the construction of a pre-engineered metal building which will provide 7,200 square feet of space to be used for the storage of aft propulsion subsystems, forward reaction control system (FRCS), installation fixtures with dollies, FRCS propellant tank removal fixtures, tank removal slings, tank covers and miscellaneous items presently stored outdoors. Storage available at the HMF is inadequate and increased vehicle flow rates will require additional support equipment. Without this storage capability all GSE will continue to be stored outdoors which accelerates deterioration and increases cleaning and maintenance costs.

F. Langley Research Center (LaRC)..	645,000
1. Construction of Carbon-Carbon Research Laboratory (1205)..................................	490,000

This project will provide a 3,000-square foot materials laboratory addition to Building 1205. Langley is expanding its research capability in carbon-carbon materials, and the additional laboratory space is needed to house the required process equipment for materials fabrication. Presently, the equipment is located in various locations around the center. Productivity will be enhanced by locating all of the process equipment in one central location. The addition will match the existing structure, and will include all necessary HVAC, electrical, and plumbing.

2. Construction of Addition to Composite Model Development Shop (1238B)...................	155,000

This project will provide a 1,350-square foot addition to Building 1238B to provide a shop area for the development of advanced composites. This operation, which is environmentally "dirty" in nature, must be isolated from the existing lay-up shop, which requires a clean environment. The work will include a high strength slab to support heavy equipment such as a walk-in freezer, and installation of all necessary HVAC, lighting, and power.

G. Lewis Research Center (LeRC)..	485,000
1. Construction of Addition to Control Room in 8-foot by 6-foot/9-foot by 15-foot Supersonic Wind Tunnel (SWT) Building (54)...	485,000

This project provides for the enlargement and upgrading of the existing 8-foot by 6-foot and 9-foot by 15-foot SWT Control Room. The work includes the construction of an approximately 1,200-square foot control room addition with basement; installation of raised floor system throughout the control room; installation of a separate instrumentation system; installation of a new air-conditioning system; installation of a new lighting system; modifications of the electrical power and grounding systems, and miscellaneous architectural work. Both the 8-foot by 6-foot and 9-foot by 15-foot test sections are operated from a single control room. This enlargement will provide relief from current overcrowded conditions and will allow concurrent operations of both tunnel test sections.

H. National Space Technology Laboratories (NSTL) 820,000

1. Addition to Standards and Calibration Laboratory 470,000

This project provides a 3,600-square foot addition to the existing Standards and Calibration Laboratory, Building 8110 to house new state-of-the-art automated, high precision standards and calibration equipment necessary to support the Space Shuttle Main Engine certification testing. The present facility does not provide the required dust, temperature, relative humidity and sound attenuation levels required for equipment calibration. The existing facility also lacks sufficient floor space, requiring laboratory instruments to be stacked on top of each other, thereby causing potential thermal instability. The addition will be environmentally controlled and will match the architecture of the existing building.

2. Addition to Earth Resources Application Building 350,000

This project provides for a 3,400-square foot addition to the Earth Resources Application Building 1210. NSTL has been assigned as Lead Center for the commercialization of the remote sensing technology. One of the primary objectives of the NASA commercialization program is to support industrial, university and government partnerships for cooperative research and development in the technical/scientific areas with high commercial viability. In order to support such partnerships, NSTL facilities and equipment must be available for industrial and university research. The addition is needed to provide space for both new data handling and processing equipment and for ADP equipment operators. The addition will be a pre-engineered structure to match the existing building. Work will include upgrading of the building electrical power system, carpentry, lighting and installing a sprinkler and HVAC system.

I. Wallops Flight Facility (WFF) 695,000

1. Construction of a Rocket Storage Facility 470,000

This project provides for the construction of a 5,000-square foot, single story Rocket Storage Facility. The building will be of metal panel fabrication with a 15-foot by 25-foot roll-up door, heating and ventilation. Due to the hazardous materials stored in the building it will be located in an area with natural earthen barricades and will be enclosed within a chain link fence. Rocket motors are currently being stored in six 40-year old magazines of 1,000 square feet each. These magazines have deteriorated and do not have sufficient structural integrity for continued storage of rocket motors.

2. Construction of Addition to the Mechanical Rigging Shop at the National Scientific Balloon Facility, Palestine, Texas.. 225,000

This project provides for the enlargement of the Mechanical Rigging Shop at the National Scientific and Balloon Facility. Additional space is required to meet the operational needs of the balloon program. This includes build-up, testing, checkout and certification of flight hardware including parachutes, cabling and gondola support items. Present quarters are insufficient to meet the increasing requirements of the program. The facility will be of pre-engineered metal construction of approximately 3,200 square feet on a concrete slab. This building extension will be equipped with standard utilities such as heating, ventilation and air-conditioning.

J. Various Locations.. 870,000

1. Construction of Support Services Building, Merritt Island STDN Station, FL............. 420,000

This project provides for the construction of a 4,400-square foot administration and facility maintenance building at the Merritt Island Launch Area Spaceflight Tracking and Data Network (STDN) station. This building will provide space for facilities shops, ground keeping equipment, logistics and tape storage, and conference and training activities. It will replace an existing wood frame administrative building and two small metal buildings used as electrical and mechanical shops. The existing wood frame administrative building has deteriorated beyond economical repair. The two metal buildings are too small and have also deteriorated beyond economical repair. These buildings have no sanitary facilities and personnel must use restroom facilities in other buildings.

2. Construction of Antenna Support Building, Canberra, Australia.......................... 450,000

This project provides for the construction of a 4,300-square foot Antenna Service Building at the Canberra Deep Space Communications Complex and for the demolition of four temporary buildings now in use. This building will be located on the site of the temporary buildings and will be of frame construction matching the architectural theme of the Canberra complex. All required supporting services and facilities are included. The existing buildings lack sanitary facilities, appropriate fire protection systems, and thermal insulation; and low ceiling heights make it difficult to perform some of the maintenance tasks.

Total.. 7,000,000

FUTURE CoF ESTIMATED FUNDING REQUIRED TO COMPLETE THIS PROJECT:

An estimated 7,000,000 to 10,000,000 per year will be required for continuing minor construction needs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

SUMMARY

FACILITY PLANNING AND DESIGN

	Amount	Page No.
Regular Requirements:	9,300,000	
Master Planning	330,000	CF 13-2
Sustaining Engineering Support	1,520,000	CF 13-2
Preliminary Engineering Reports and Related Special Engineering Support	2,450,000	CF 13-5
Final Design	5,000,000	CF 13-6
Other Requirements:	4,700,000	
Space Shuttle Facility Planning and Design	900,000	CF 13-6
Payload Facility Planning and Design	600,000	CF 13-6
Space Station Support Facilities Planning and Design	3,200,000	CF 13-7
Total	14,000,000	

CONSTRUCTION OF FACILITIES

FISCAL YEAR 1987 ESTIMATES

PROJECT TITLE: Facility Planning and Design	
	FY 1987 CoF ESTIMATES: $14,000,000
FY 1985: $12,000,000	FY 1986 $11,000,000

The funds requested in this estimate are required to provide for the following advance planning and design activities related to facilities activities and projects:

a. The accomplishment of necessary development and master planning for field installations and, where not otherwise provided for, the provision of continuing engineering support and special engineering management and other services.

b. The preparation of preliminary engineering reports, costs estimates, and design and construction schedules.

c. The preparation of final construction plans, specifications, and associated cost estimates and schedules required to implement construction projects.

d. The accomplishment of facilities siting and other investigations, studies and reports.

Regular requirements encompass the basic purposes outlined above. The "other requirements," while also in support of "regular" purposes, cover those special needs related to large, complex projects or specific programs considered to represent high potential future construction requirements for which early definition is essential. The large projects require more planning and longer lead time. Much of this planning must be completed prior to inclusion of the project in a budget request.

1. REGULAR REQUIREMENTS 9,300,000

A. Master Planning 330,000

Provides for update and development of existing field installation master plans. This effort includes facility studies, site investigations, and analyses of utility systems. The master plan document will be updated to reflect as-built conditions since issue of previous plans, and to graphically represent the five-year facility plan baseline for future development.

The NASA field center master plans are generally updated at four to five year intervals. On an agencywide basis, the level of effort remains fairly constant. The master plans are essential as reference documents for land use planning, physical relationships of facilities, and proper orientation and arrangement of facilities. Representative candidates for FY 1987 master planning are:

(1) Lewis Research Center

An update of the facilities inventory base to reflect new construction, utility system revisions, changes for additions to research missions, and revised five-year planning.

(2) National Science Technology Laboratories

An update to reflect new construction, revised land use planning, and changes to five-year planning.

(3) Michoud Assembly Facility

An update to reflect as-built conditions of facilities and utilities and revisions to land use planning.

B. Sustaining Engineering Support 1,520,000

Provisions for facility studies and specific engineering support continue in importance as evidenced in recent years, and must be given high priority throughout FY 1987. These efforts are important due to changing cost trends in construction materials and fuels; the continuing importance of energy conservation and efficiency; and the operation and maintenance costs for the physical plant.

The following items are included in the FY 1987 requirements:

(1) Building Research Board

Covers annual support to the Federal Construction Council's (FCC) operations and provides for special studies that the Council will perform throughout FY 1987 to help advance the science and technology of Federal Government building and construction. The FCC is subordinate to the Building Research Board, National Academy of Sciences, and its activities are supported by several Federal agencies including NASA.

(2) Utilities Services/Rates Analysis

Provides resources for the support of utilities procurement and utilities control systems. This includes, but is not limited to, technical assistance, surveillance, and recommendations with regard to utility rates, contract negotiations, systems operations, and utilities control systems. Because of the great magnitude of energy costs, these services are an annual requirement and continue to be essential.

These resources enable the Agency to insure that fair and reasonable rates are charged under its major utility contracts. Essential and valuable technical assistance is provided to our field installations so that effective negotiations can be conducted with utility companies. Several major utility contracts per year require technical assistance as utility contracts are renewed throughout the Agency.

NASA's significant ongoing investment in utility control and management systems requires a high level of technical maintenance and support. The proper function and operation of the equipment are essential in order to realize the benefits. These resources provide the high technical capabilities needed to manage the system and insure proper operation and use.

These resources will provide for an updating of our system for forecasting utility costs and rates, so that better and more reliable utility budget requirements can be established. The accuracy and credibility of forecasts impact the Agency's planning for other resources.

These and other similar utility system services are provided for by the requested resources in order to ensure technical competence and properly manage this function.

(3) Facility Operation and Maintenance Analysis

Provides for continued engineering support for implementing improvements at NASA field installations relative to manpower utilization, work control systems, preventive maintenance, facilities

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Special Analyses

management and reporting systems. Improvements will also involve techniques to identify where and how increases in productivity are possible. Included in this activity are field surveys to be conducted on a priority basis at selected NASA field installations to evaluate the effectiveness of the operations and maintenance management systems.

(4) Value Engineering Cost Validations and Analyses

Provides for engineering services to improve cost-effectiveness of facility projects by subjecting project design criteria, specifications and working drawings for specific material components and systems to a detailed independent review by engineering specialists in the particular area of involvement. Also provides services necessary to accurately predict and validate facility costs which will aid in resources planning for the various field installations.

(5) Facilities Utilization Analyses

Provides for the analyses of agencywide facilities utilization data covering: (1) office and other types of building space; (2) designated major technical facilities; and (3) special studies comparing the utilization of technical facilities which are similar in type or capability, such as wind tunnels. Such analyses provide for: (1) insights into and development of better methods of identifying underutilized facilities; (2) improved techniques to quantify level of facilities use; and (3) actions to improve facilities utilization. Work provides for review of each installation's inventory data base in support of the facilities utilization program. Surveys are necessary to validate the reported data in relation to a specific problem or need, and to assist in providing a credible foundation for plans to improve the utilization of facilities.

(6) Environmental Studies

Provides for the identification of potential environmental problems or the quick resolution of any related controversies at the NASA field installations. These conditions may be brought about by:

- New federal, state and local environmental regulations, emissions standards and environmental management planning programs that must be considered at various installations;

- Changes resulting from new or expanded program activities, new facilities, or major site expansions at NASA installations; and,

- Changes that take place in the external environmental conditions at NASA installations.

Early identification of potential environmental problems and quick resolution of these and related controversies at the installations are important. Project managers and facility planners require up-to-date, accurate information to comply with legal and regulatory requirements.

C. Preliminary Engineering Reports and Related Special Engineering Support................. 2,450,000

(1) Preliminary Engineering Reports (PER's).. (1,950,000)

Preparation of PER's, investigations, and project studies related to proposed facility projects in the FY 1989 and FY 1990 Construction of Facilities programs are provided for by this estimate. These reports are required to permit the early and timely development of the most suitable project to meet the stated programmatic and functional needs. Reports provide basic data, cost estimates and schedules relating to future budgetary proposals. This request provides for PER's; associated with proposed construction except as provided for in other requirements (paragraph 2) for Shuttle , Space Station, and Payload initiatives.

The estimated cost of PER support for FY 1989 construction projects is $1,300,000 which will permit updating of PER's for $30-35 million in construction, and the development of new PER's for an additional $40-50 million in projects.

An additional $650,000 has been included in this line for the completion of new PER's for approximately $30-35 million of construction projects which will be high priority candidates for inclusion in the FY 1990 Construction of Facilities program. The activity associated with FY 1990 will be confined to the highest priority candidates.

(2) Related Special Engineering Support.. (500,000)

Investigations and project studies related to proposed facility projects to be included in the subsequent Construction of Facilities programs are provided for by this estimate. Such studies involve documentation and validation of "as built" conditions, survey/study of present condition of such items as roofing and cooling towers, utility plant condition and operational modes, analysis and support of environmental impact assessments and statements, and other like studies. These studies are required to allow for the timely development of projects to meet the stated functional needs and to provide basic data, cost estimates and schedules for related future budgetary proposals.

D. Final Design 5,000,000

The amount requested will provide for the preparation of designs, plans, drawings, and specifications necessary for the accomplishment of projects other than Space Shuttle, Spacelab, and Payloads and the Space Station. Amounts required for those efforts are included under other requirements (paragraph 2). Projects involved are planned for inclusion in the FY 1988 and FY 1989 programs. The goal is to obtain better facilities on line earlier at a lower cost.

The request will provide for final design work associated with construction proposed for the FY 1988 Program, estimated to cost $65 to $70 million, and for $10 to $15 million of high potential projects proposed of the FY 1989 program. The amount included for FY 1988 candidates and for residual requirements of this nature which have accumulated from prior years' final design activities is $4,100,000. For FY 1989, $900,000 is included and the supporting rationale is much the same as that set out in the PER estimate.

2. OTHER REQUIREMENTS 4,700,000

Other facilities planning and design requirements primarily associated with specific space programs characterized by large size, long planning cycle, and/or complexity of scope are included in this particular request. These programs require a level of planning effort and length of design time beyond the more routine facility projects. These requirements must be provided beyond the regular and most recurrent facility planning and design needs.

A. Space Shuttle Facility Planning and Design 900,000

These resources provide for early and progressive design, final drawings, specifications, and site investigations for future Space Shuttle facilities in order to insure the best design, good cost estimates and realistic construction schedules. The Shuttle operational era requirements include expansion of Shuttle processing, repair and maintenance facilities to meet an increasing launch rate, construction of operations personnel facilities, modification to the launch complex support facilities and modifications at various locations for space engine enhancement and testing.

B. Payload Facility Planning and Design 600,000

Support of the operational phase of the STS payloads processing program will necessitate preparation of Preliminary Engineering Reports, facility site investigations, design of facility projects, and studies to determine facility capabilities. Included are facilities for payload operations and control payload processing of the larger and more numerous payloads, as well as facility projects for logistics and maintenance of payloads and storage of associated flight and support equipment.

C. Space Station Support Facilities Planning and Design 3,200,000

This requirement is primarily for preparation of preliminary engineering reports and final design drawings, specification and associated site investigation required for construction of future Space Station facilities at various locations. Included are engineering and system management type test beds, data management, Mission Control Centers research laboratories, simulation, integration, processing and prelaunch checkout facilities.

Total $14,000,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1986 ESTIMATES

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THIS DOCUMENT DOES NOT REFLECT: (1) THE FY 1986 REDUCTIONS THAT ARE LIKELY TO RESULT UNDER THE BALANCED BUDGET AND EMERGENCY DEFICIT CONTROL ACT OF 1985; OR (2) THE EFFECTS RESULTING FROM THE LOSS OF THE CHALLENGER AND CREW ON JANUARY 28, 1986. PROPOSED CHANGES IN PROGRAM PLANS AND BUDGET ESTIMATES WILL BE TRANSMITTED LATER.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987 ESTIMATES

GENERAL STATEMENT

The Research and Program Management appropriation provides funds for the performance and management of research, technology and test activities at NASA installations, and the planning, management and support of contractor research and development tasks necessary to meet the Nation's ongoing objectives in aeronautical and space research. The objectives of the activities funded by the Research and Program Management appropriation are to (1) provide the civil service staff with the technical and management skills, to conduct the full range of programs for which NASA is responsible, (2) provide base maintenance of facilities and manage its use in support of research and development programs, and (3) provide effective and efficient technical and administrative support for the research and development programs. For 1987, an appropriation of $1,441,000,000 is requested.

The Research and Program Management appropriation provides funding for the 21,800 permanent and temporary civil service personnel at eight major installations and Headquarters. This civil service workforce is NASA's most important resource and is vital to future space and aeronautics research activities. About seventy percent of the Research and Program Management appropriation provides for the salaries and related costs of this civil service workforce. Two percent of this appropriation is used for travel, critical to manage successfully the Agency's in-house and contracted programs. The remaining amount of the Research and Program Management appropriation provides for the research, test and operational facility support, and for related goods and services necessary to operate efficiently and effectively the NASA installations and to accomplish NASA's approved missions.

NASA field centers report to the Program Associate Administrator responsible for the major portion of their technical programs. The principal roles assigned each installation based on demonstrated capabilities and capacities to meet NASA's overall program goals are as follows:

Office of Space Flight:

Johnson Space Center: Management of the integrated Space Shuttle program, including orbiter production and operation; selection and training of astronauts and mission specialists; Space Transportation System Operations including mission planning, operational procedures and flight control; and management of the integrated Space Station program and definition/development of Space Station hardware.

Kennedy Space Center: Launch of Space Shuttle flights; management of the ground operational phase of the Space Transportation System; the preparation and launch of payloads on the Space Shuttle and expendable launch vehicles, and Space Station operational readiness planning.

Marshall Space Flight Center: Management of the Space Shuttle main engine, solid rocket booster and external tank projects; management of NASA's activities on the Spacelab project; management of large automated spacecraft projects such as the Hubble Space Telescope; conduct and development of experiments in materials processing in space; and definition/development of the Space Station common module and laboratory outfitting.

National Space Technology Laboratories: Support Space Shuttle engine procurement and testing; Earth resources research and technology transfer; and provision of support service functions for other Government agencies located on site.

Office of Space Science and Applications

Goddard Space Flight Center: Development and operation of Earth orbital flight experiments and automated spacecraft to conduct scientific investigations and demonstrate practical applications; management of tracking and data acquisition activities for Earth orbital missions; management of the Delta launch vehicle program; management and launch of sounding rockets and balloons; operation of an instrumented flight range for aeronautical and space research; and definition/development of the Space Station platforms and payload accommodations. The Wallops Flight Facility is an operational element and component installation of the Goddard Space Flight Center.

Office of Aeronautics and Space Technology:

Ames Research Center: Conduct of short haul aircraft and rotorcraft research and technology; computational fluid dynamics; responsible for computational aerodynamics and for the Transatmospheric Research and Technology program; planetary probe research; life sciences; aeronautical flight research and testing; and operation of an alternate landing site for Space Shuttle operational missions. The Dryden Flight Research Facility, an operational element and component installation of Ames located in the Mojave Desert, is the site of advanced flight testing and Shuttle landings.

Langley Research Center: Conduct of long haul aircraft research and technology, emphasizing fuel conservation, safety and environmental effects; aerospace structures technology; environmental quality monitoring by remote sensing; advanced space systems technology; and responsible for research in the areas of structures and materials, guidance and controls and airframe/propulsion integration of the Transatmospheric Research and Technology program.

Lewis Research Center: Conduct of aeronautical and space propulsion research and technology; responsible for research on propulsion for the Transatmospheric Research and Technology program; space communications research and technology; space energy systems research and technology; definition/development of the Space Station power system; and development of the Centaur cryogenic upper stage for use in the Space Shuttle and management of the Centaur expendable launch vehicle program.

The 1987 budget provides the necessary resources to apply these in-house capabilities to program activities. Detailed data on funding requirements are provided in the section on each installation. A summary description of, and the funding required by functional category, include:

1. Personnel and Related Costs ($980,865,000): Includes salaries and benefits, the government's contribution to medicare for NASA permanent and temporary civil service employees, and for personnel of other Government agencies detailed to NASA. This category also includes other personnel related costs, such as moving expenses (excluding the associated travel of people), recruiting and personnel investigation services provided by the Office of Personnel Management, and the training of NASA civil service employees.

2. Travel ($33,700,000): Includes the cost of transportation, per diem, and related travel expenses of civil service employees who travel for the direction, coordination and management of all NASA program activities including overseas launch and tracking sites; for contract management; for flight mission support; for meetings and technical seminars and symposia; and for permanent and temporary relocations. Payments to interagency motor pools are included under Operation of Installation (Management and Operations).

3. Operation of Installation ($426,435,000): Provides a broad range of services, supplies, and equipment in support of each center's institutional activities. These are divided into three major subfunctional areas: Facilities Services, covering the cost of rental of real property, maintaining and repairing institutional facilities and equipment, and the cost of custodial services and utilities; Technical Services, covering the cost of automatic data processing for management activities, and the cost of educational and informational programs and technical shops supporting institutional activities; and Management and Operations, covering the cost of administrative communications, printing, transportation, medical, supply, and related services. The amounts by major subcategory are as follows:

   A. Facilities Services ($231,694,000): Includes rental of real property; the cost of maintenance, repair and related activities for facilities and equipment; custodial services; minor modifications and alterations; and utilities services. The Hazardous Substances Release Assessment activity ($5,000,000) to conduct a review of environmental problems in a planned and orderly manner is included in this function in 1987.

B. Technical Services (86,380,000): Includes the cost of general purpose automatic data processing for management activities; education and informational programs; shops and other essential technical services. The Automated Systems Development program ($7,500,000) to be initiated in 1987 is included here.

C. Management and Operations ($108,361,000): Includes the cost of administrative communications; printing and reproduction; administrative supplies; general purpose materials and equipment; transportation of equipment and supplies (including payments to interagency motor pools); medical services and other support.

SUMMARY OF THE BUDGET PLAN BY FUNCTION

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
I. Personnel and Related Costs......	954,592	973,813[1]	969,104	980,865
II. Travel...........................	29,704	31,000	31,000	33,700
III. Operation of Installation........	347,484	382,187	361,896	426,435
A. Facilities Services..........	(176,808)	(212,273)	(199,150)	(231,694)[2]
B. Technical Services...........	(60,652)	(66,071)	(65,838)	(86,380)[3]
C. Management and Operations....	(110,024)	(103,844)	(96,908)	(108,361)
Total.........................	1,331,780	1,387,000[1]	1,362,000	1,441,000

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[1] Adjusted to include $42,000 to cover the cost of the pay freeze vs. originally proposed pay cut in FY 1986

[2] Includes $5,000 for Hazardous Substances Release Assessments

[3] Includes $7,500 for the agencywide Automated Systems Development Program

SUMMARY OF CHANGES FROM THE 1986 BUDGET ESTIMATE TO THE 1986 CURRENT ESTIMATE

Of the 1986 Research and Program Management request of $1,387,000,000 (adjusted for the civil service pay freeze in lieu of the planned 5% pay cut), $1,362,000,000 has been appropriated. The changes from the original request are summarized as follows:

	(Thousands of Dollars)
1986 Budget Estimate	$1,345,000
Adjustment for the Pay Freeze in Lieu of the Planned 5% Pay Cut	42,000
Congressional Action	-25,000
Appropriation and FY 1986 Current Estimate	$1,362,000

Of the $25.0 million reduction from the adjusted request $4.7 million will be accomplished by adjusting Personnel and Related Costs in order to meet the requirement to calculate salaries based on 2087 hours and a refinement of the overall cost estimate. In Operation of Installation, cost reductions totalling $20.3 million will be achieved by the delay and deferral of the purchases of supplies, materials, equipment and contractual effort and by the rephasing of obligation plans for support service contracts. These reductions place a burden on NASA in providing adequate institutional support to the research and development programs, but the actions planned are designed to mitigate adverse impact as much as possible.

BASIS OF THE 1987 ESTIMATE

The 1987 budget estimate of $1,441,000,000, an increase of $79.0 million over the current 1986 estimate provides for: the personnel and related costs of 21,800 full-time equivalent (FTE) civil service workyears; a minimum level of travel to support Agency missions and programs; support service contractor effort at the anticipated wage-rates; a full year obligations for such contracts; utility usage consistent with programmatic requirements at projected rates; and supplies, materials, equipment and other minor contracts and services at anticipated price levels. The 1987 Research and Program Management Budget provide for three specific items not in the 1986 plan: $7.4 million for procurement of badly needed administrative computers at Langley, Lewis, Goddard, and Headquarters; $5.0 million for Hazardous Substances Release Assessments; and $7.5 million to begin an Automated Systems Development Program. The balance of the changes in this appropriation request reflect a constant level of operations at expected price levels.

The Research and Program Management appropriation request for 1987, by functional category is summarized as follows:

1. Personnel and Related Costs ($980,865,000): The 1987 estimate for Personnel and Related Costs is $11.8 million higher than 1986. It is based on 21,800 FTE workyears and reflects the alteration in the mix between reimbursed and direct costs of civil service; and the normal costs associated with within-grades, career development, merit pay, etc.

2. Travel ($33,700,000): Because the vast majority of NASA funds are spent out of house, travel for both programmatic and management purposes is integral to the effective and economical accomplishment of program objectives. In addition, because NASA's civil service workforce is so heavily technical (over 50 percent of NASA's permanent personnel are degreed scientists and engineers) travel to scientific and technical meetings, seminars and symposia is important for the interchange of information. In 1987, the growth in travel over 1986 is the increase associated with the expected costs at a level of travel commensurate with programmatic responsibilities.

3. Operation of Installation ($426,435,000): The 1987 plan provides for anticipated changes in the price levels of support service contractor wage rates and utility rates, the alteration in the funding plans from reimbursable launch vehicles activities, the full year obligation of support service contracts, and in the price levels for supplies, materials, and equipment. In addition, funds are requested for badly needed administrative computer upgrades and additions at Langley, Lewis, Goddard, and Headquarters; for hazardous substances release assessments; and for an Automated Systems Development Program. The amounts by subcategory are as follows:

A. Facilities Services ($231,694,000): The 1987 estimate, an increase of $32,544,000 over the 1986 current estimate, covers the full year obligation of support service contracts, and anticipated rate and price increases for utilities, support contractor wage rates, supplies, materials, equipment and minor contractual effort. In addition, $5.0 million is included for hazardous substances release assessment which will provide for a systematic and comprehensive evaluation of potential hazardous environmental areas at NASA centers and other controlled sites. Funding of this activity has become imperative because of recent legislative, executive and judicial actions in the environmental field.

B. Technical Services ($86,380,000): The $20,542,000 increase in 1987 covers anticipated support service contractor wage-rates, the full year obligation for such contracts, and the anticipated cost of supplies, materials, equipment and minor contractual effort. Of the increase, $7.4 million is requested for the replacement and/or upgrading of administrative computing facilities at Langley, Lewis, Goddard, and Headquarters; and $7.5 million is requested to begin an Automated Systems Development Program designed to share technology and experience on an agencywide basis to increase efficiency and reduce costs in developing administrative automated information systems. The Automated Systems Development Program will enable NASA to meet requirements of the Paperwork Reduction Act of 1980 and to respond to Reform 88 initiatives.

C. Management and Operations ($108,361,000): The $11,453,000 increase in this subcategory is the result of increased costs of supplies, materials, equipment and minor contractual effort, the anticipated change in support service contractor wage-rates, and the full year obligation of such contracts.

In summary, the 1987 budget requirement of $1,441,000,000 is to provide for 21,800 full-time equivalent civil service workyears and to support the activities at eight NASA installations and Headquarters, consistent with the Research and Development, Space Flight, Control and Data Communications, and Construction of Facilities program plans.

DETAIL OF CONTENTS BY FUNCTION

I. PERSONNEL AND RELATED COSTS

A. COMPENSATION AND BENEFITS:

1. Compensation:

   a. Permanent Positions: This part of Personnel and Related Costs covers the salaries of the full-time permanent civil service workforce and is the largest piece of this functional category.

   b. Other Than Full-Time Permanent Positions: This category includes the salaries of NASA's non-permanent workforce. Programs such as students participating in cooperative training, summer employment, youth opportunity, and temporary clerical support are covered in this category.

   c. Reimbursable Detailees: In accordance with existing agreements, NASA reimburses the parent Federal organization for the salaries and related costs of persons detailed to NASA.

   d. Overtime and Other Compensation: Overtime, holiday, post and night differential, and hazardous duty pay are included in this category. Also included are incentive awards for outstanding achievement and superior performance.

2. Benefits: In addition to compensation, NASA, as authorized and required by law, makes the employer's contribution to personnel benefits. These benefits include contributions to the Civil Service Retirement Fund, employees' life and health insurance, payments to the Medicare fund for permanent employees, and social security contributions for non-permanent personnel. Payments to the civil service retirement fund for re-employed annuitants and for severance pay to former employees involuntarily separated through no fault of their own are also included.

B. SUPPORTING COSTS:

1. Transfer of Personnel: Provided under this category are relocation costs required by law, such as the expenses of selling and buying a home, and the movement and storage of household goods.

2. Office of Personnel Management Services: The Office of Personnel Management is reimbursed for activities such as security investigations on new hires, recruitment advertising, and career-maturity surveys.

3. Personnel Training: Training is provided within the framework of the Government Employees Training Act of 1958. Part of the training costs consists of courses offered by other Government agencies, and the remainder provides for training through nongovernment sources.

II. TRAVEL

A. Program Travel:

The largest part of travel is for direction, coordination and management of program activities including international programs and activities. The complexity of the programs and the geographical distribution of NASA installations and contractors necessitate the need for this category of travel. As projects reach the flight stage, support is required for prelaunch activities, including overseas travel to launch and tracking sites. The amount of travel required for flight projects is significant as it is directly related to the number of systems and subsystems, the number of design reviews, and the number and complexity of the launches and associated ground operations.

B. Scientific and Technical Development Travel:

Travel to scientific and technical meetings and seminars permits employees engaged in research and development to participate in both Government sponsored and nongovernment sponsored activities. This participation allows personnel to benefit from exposure to technological advances which arise outside NASA, as well as allowing personnel to present both accomplishments and problems to their associates and provides for the dissemination of technical results to the United States community. Many of the Government sponsored meetings are working panels convened to solve certain problems for the benefit of the Government.

C. Management and Operations Travel:

Management and operations travel provides for the direction and coordination of general management matters and travel by officials to review the status of programs. It includes travel by functional managers in such areas as personnel, financial management and procurement. This category also includes the cost of travel in and around the Installations; travel of unpaid members of research advisory committees; and initial duty station, permanent change of assignment, and other family travel expenses. Payments to interagency motor pools are included in the Operation of Installation function (Management and Operations subfunction).

III. OPERATION OF INSTALLATION

Operation of Installation provides a broad range of services, supplies, and equipment in support of the centers' institutional activities. These are divided into three major subfunctional areas: Facilities Services (the cost of renting real property, maintaining and repairing institutional facilities and equipment, and the cost of custodial services and utilities); Technical Services (the cost of automatic data processing for management activities, and the cost of educational and information programs and technical shops supporting institutional activities); and Management and Operations (the cost of administrative communications, printing, transportation, medical, supply, and related services). A description of each major subfunction follows:

A. Facilities Services:

1. Rental of Real Property: Rental of real property includes the rental of building space directly by NASA or through the General Services Administration to meet offsite office, warehousing, and other requirements which cannot otherwise be provided in existing buildings at the NASA Installation. Most of the funding is required for rental of the NASA Headquarters complex of buildings in the District of Columbia, and nearby Maryland and Virginia that are either Government-owned or leased. NASA must provide rental payments to the General Services Administration in accordance with P.L. 92-313 for these facilities.

2. Maintenance and Related Activities: Maintenance and related activities include the recurring day-to-day maintenance of facilities (grounds, buildings, structures, etc.) and equipment accomplished by non-Civil Service personnel. This involves the mowing and care of grassy areas, care of trees and shrubs, elevators, cranes, pressure vessel inspections, painting and protective coatings, general buildings maintenance, and the maintenance of installed mechanical, electrical, and other systems. In addition, this item includes feasibility studies, project design, construction supervision, inspection, and other institutional facility engineering functions. Included also are any applicable costs associated with recurring facility work as well as materials, hardware, and equipment used in facility maintenance activities, whether accomplished by civil service personnel or contractors. In the cost of equipment, related maintenance and other services are reflected for office, shop, laboratory and other facilities equipment as well as administrative internal communications and television monitoring equipment.

3. Custodial Services: Custodial services include janitorial and building cleaning services, pest control, fire protection services, security services including badging and identification, lock and safe repair, trash and refuse handling, window blinds and light fixture cleaning, and laundry and dry cleaning of facility related items.

4. Utilities Services: Utilities services include the purchase of utilities such as electricity, natural gas, fuel oil, coal, steam, propane, and other fuel commodities as well as water and sewage treatment services. Also included are the related maintenance and operating costs of the utility plants and systems.

B. Technical Services:

1. Automatic Data Processing:

   a. Equipment: This category provides for the lease, purchase and maintenance of general purpose data processing equipment which supports institutional operations at each installation. Excluded is equipment dedicated to specific research or operational systems which is funded from the Research and Development or the Space Flight, Control and Data Communications appropriations.

   b. Operations: Operations services include programming, computer operations and related services for institutional applications including payroll, financial management, security, maintenance, personnel, logistics, and procurement records and reports.

2. Scientific and Technical Information and Educational Programs:

   a. Libraries: The technical libraries are established to provide installation staff with books, periodicals, technical reports and other scientific documentation.

   b. Education and Information Programs: The educational and informational programs provide for the documentation and dissemination of information about the Agency's programs to the general public, the educational community at the elementary and secondary levels, and the mass communications media. Assistance to the mass communications media includes the assembly and exposition of newsworthy material in support of requests in the form of press kits, news releases, television and radio information tapes and clips, and feature material.

   c. Shop and Support Services: Shop and support services include general fabrication shops, reliability and quality assurance activities, safety, photographic services, graphics, and audio-visual material.

C. Management and Operations:

1. Administrative Communications: Included in this category are costs not dedicated to a specific program or project, and cover leased lines, long distance tolls (including FTS charges), teletype services, and local telephone service.

2. Printing and Reproduction: Included in this category are the costs for duplicating, blueprinting, microfilming, and other photographic reproductions. Also included in this category are Government Printing Office printing costs, contractual printing and the related composition and binding operations.

3. Transportation: Transportation services include the operation and maintenance of all general purpose motor vehicles used by both civil service and support contractor personnel. The cost of movement of supplies and equipment by commercial carriers and payments to interagency motor pools are also in this category.

4. Installation Common Services: Installation common services include support activities at each installation such as: occupational medicine and environmental health; mail service; supply management; patent services; administrative equipment; office supplies and materials; and postage.

DISTRIBUTION OF PERMANENT CIVIL SERVICE WORKYEARS BY INSTALLATION

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
Johnson Space Center	3,247	3,201	3,252	3,253
Kennedy Space Center	2,064	2,054	2,035	2,030
Marshall Space Flight Center	3,263	3,229	3,229	3,234
National Space Technology Laboratories	114	106	119	119
Goddard Space Flight Center	3,559	3,569	3,576	3,576
Ames Research Center	2,044	2,001	2,029	2,029
Langley Research Center	2,824	2,808	2,812	2,812
Lewis Research Center	2,647	2,582	2,655	2,655
Headquarters	1,267	1,292	1,242	1,242
Inspector General	94	97	97	97
Subtotal, Full-Time Permanent Workyears	21,123	20,939	21,046	21,047
Other Than Full-Time Permanent Workyears	[illegible]70	861	754	753
Total, Ceiling Controlled Civil Service	21,993	21,800	21,800	21,800

SUMMARY OF BUDGET PLAN BY INSTALLATION

(Thousands of Dollars)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Johnson Space Center	214,811	220,403	209,987	218,110
Kennedy Space Center	184,488	193,419	194,700	208,096
Marshall Space Flight Center	198,069	202,363	200,095	203,847
National Space Technology Laboratories	10,669	11,356	10,907	11,453
Goddard Space Flight Center	196,857	206,628	203,930	214,338
Ames Research Center	120,290	127,992	124,698	133,913
Langley Research Center	147,122	154,216	150,029	155,033
Lewis Research Center	137,383	144,785	142,977	150,320
Headquarters	116,866	120,020	119,166	127,896
Inspector General	5,225	5,818	5,511	5,494
Agencywide Activities	---	---	---	12,500
Total, Research and Program Management	1,331,780	1,387,000[1]	1,362,000	1,441,000

[1] Includes add-back of $42,000 for the pay freeze vs. a pay cut in FY 1986.

DISTRIBUTION OF PERMANENT CIVIL SERVICE WORKYEARS BY PROGRAM

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
RESEARCH AND DEVELOPMENT	11,762	12,470	12,596	12,853
Space Station	1,164	1,830	1,768	2,128
Space Transportation Capability Development	1,447	1,367	1,487	1,504
Space Science and Applications	4,394	4,219	4,312	4,188
Physics and astronomy	2,414	2,334	2,460	2,252
Life sciences	287	251	253	251
Planetary exploration	191	179	181	180
Space applications	1,502	1,455	1,418	1,505
Commercial Programs	67	107	110	118
Technology Utilization	40	45	39	37
Commercial Use of Space	27	62	71	81
Aeronautics and Space Technology	4,661	4,916	4,889	4,885
Aeronautical research and technology	3,485	3,561	3,595	3,418
Space research and technology	1,176	1,355	1,294	1,275
Trans-atmospheric Research and Technology	---	---	---	192
Tracking and Data Acquisition	29	31	30	30
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	4,493	3,838	3,868	3,613
Shuttle Production and Operational Capability	1,097	813	886	735
Space Transportation Operations	2,727	2,339	2,328	2,234
Space and Ground Network, Communications and Data Systems	669	686	654	644
Subtotal, Direct	16,255	16,308	16,464	16,466
CENTER MANAGEMENT AND OPERATIONS SUPPORT	4,868	4,631	4,582	4,581
Subtotal, full-time permanents	21,123	20,939	21,046	21,047
Other than full-time permanents	870	861	754	753
Total, Permanent Positions	21,993	21,800	21,800	21,800

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1987 ESTIMATES
RESEARCH AND PROGRAM MANAGEMENT
DISTRIBUTION OF BUDGET PLAN BY FUNCTION BY INSTALLATION

(THOUSANDS OF DOLLARS)

FUNCTION	TOTAL NASA	JOHNSON SPACE CENTER	KENNEDY SPACE CENTER	MARSHALL SPACE FLIGHT CENTER	NATIONAL SPACE TECHNOLOGY LABORATORIES	GODDARD SPACE FLIGHT CENTER	AMES RESEARCH CENTER	LANGLEY RESEARCH CENTER	LEWIS RESEARCH CENTER	HEADQUARTERS	INSPECTOR GENERAL	AGENCYWIDE ACT
PERSONNEL AND RELATED COSTS												
1985 ACTUAL	954,592	155,283	92,462	149,458	5,013	154,834	93,439	116,525	110,060	72,774	4,736	
1986 BUDGET	973,813	155,988	94,551	151,341	5,104	160,724	93,756	119,762	112,741	74,609	5,237	
1986 CURRENT	969,104	156,506	93,990	150,523	5,142	160,859	94,564	117,356	111,482	73,519	4,954	
1987 ESTIMATE	980,865	157,729	96,906	152,178	5,193	162,915	96,698	118,595	112,842	73,701	5,000	
TRAVEL												
1985 ACTUAL	29,704	4,756	2,510	5,075	190	4,458	2,313	2,735	2,626	4,623	218	
1986 BUDGET	31,060	4,963	2,350	5,300	200	4,314	2,720	3,175	2,726	5,000	252	
1986 CURRENT	31,000	4,808	2,464	5,220	200	4,600	2,717	2,035	2,622	5,187	239	
1987 ESTIMATE	33,790	5,350	2,070	5,670	210	4,909	2,983	3,220	2,897	5,355	245	
OPERATION OF INSTALLATION												
1985 ACTUAL	347,484	54,772	89,516	43,536	5,466	37,565	24,338	27,862	24,609	39,469	271	
1986 BUDGET	382,187	59,452	96,518	45,722	6,052	41,590	31,516	31,279	29,318	40,411	329	
1986 CURRENT	361,896	48,673	98,237	44,344	5,565	38,471	27,417	29,538	28,873	40,460	318	
1987 ESTIMATE	426,435	55,031	109,220	45,999	6,050	46,523	34,232	33,218	34,581	48,840	241	12,500
TOTAL												
1985 ACTUAL	1,331,780	214,811	184,488	198,069	10,669	196,857	120,290	147,122	137,303	116,866	5,225	
1986 BUDGET	1,387,000	220,403	193,419	202,363	11,356	206,628	127,992	154,216	144,785	120,026	5,818	
1986 CURRENT	1,362,000	209,987	194,700	200,095	10,907	203,930	124,698	150,029	142,977	119,166	5,511	
1987 ESTIMATE	1,441,000	218,116	208,096	203,847	11,453	214,338	133,913	155,033	150,320	127,896	5,486	12,500

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED APPROPRIATION LANGUAGE

RESEARCH AND PROGRAM MANAGEMENT

For necessary expenses of research in Government laboratories, management of programs and other activities of the National Aeronautics and Space Administration, not otherwise provided for, including uniforms or allowances therefor, as authorized by law (5 U.S.C. 5901–5902); awards; lease, hire, maintenance and operation of administrative aircraft; purchase (not to exceed thirty-three for replacement only) and hire of passenger motor vehicles; and maintenance and repair of real and personal property, and not in excess of $100,000 per project for construction of new facilities and additions to existing facilities, repairs, and rehabilitation and modification of facilities; [$1,367,000,000] *$1,441,000,000*: *Provided*, That contracts may be entered into under this appropriation for maintenance and operation of facilities, and for other services, to be provided during the next fiscal year: *Provided further*, That not to exceed $35,000 of the foregoing amount shall be available for scientific consultations or extraordinary expense, to be expended upon the approval or authority of the Administrator and his determination shall be final and conclusive[: *Provided further*, That of funds provided for the National Aeronautics and Space Administration under this or any other account, $400,000 shall be available for the activities of the National Commission on Space, established by the National Aeronautics and Space Administration Authorization Act, 1985 (Public Law 98–361; 98 Stat. 422)].

[SEC. 416. Notwithstanding any other provision of this Act, amounts otherwise provided by this Act for the following accounts and activities are reduced by the following amounts:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

"Research and program management", $5,000,000;] *(Department of Housing and Urban Development-Independent Agencies Appropriations Act, 1986; additional authorizing legislation to be proposed.)*

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987 ESTIMATES

LYNDON B. JOHNSON SPACE CENTER

DESCRIPTION

The Lyndon B. Johnson Space Center (JSC) is located approximately 20 miles southeast of downtown Houston, Texas. Total NASA-owned land at the Houston site consists of 1,647 acres. The Center also utilizes an additional 54,080 acres at the White Sands Test Facility, Las Cruces, New Mexico. The total capital investment of the JSC, including fixed assets in progress and contractor-held facilities at various locations and the White Sands Test Facility, as of September 30, 1985 was $828,157,000.

CENTER ROLES AND MISSIONS

JSC was established in November 1961, in response to the need in NASA for a Center to manage the design, development and manufacture of manned spacecraft; for selection and training of astronaut crews; and the conduct of manned space flight missions. This need continued as the Nation proceeded toward more ambitious undertakings such as the Apollo program, the Skylab program, the Apollo-Soyuz Test Project, the Space Shuttle program, and currently the Space Station program. To meet this responsibility, JSC has developed unique areas of recognized technical excellence within the civil service staff and facilities of superior merit, which constitute a National resource. The principal and supporting roles are:

Space Station - lead center for management of the definiton phase contracts, in-house systems engineering and integration, utilization, advanced technology development, focused technology and operational readiness. Includes station configuration management, station subsystem development and overall system design.

Manned Vehicles - development of manned space vehicles and associated supporting technology, including:

Space Shuttle Production and Operations Capability - development of the Orbiter and lead Center for management of the Shuttle system; including Shuttle configuration management, Shuttle engineering and Orbiter operational procurement.

STS Operations - operational planning, crew selection and training, medical operations, STS flight control, experiment/payload flight control for attached payloads and STS utilization planning/payload accommodation studies.

Environmental and Crew Support Systems - develop and demonstrate Environmental Control and Life Support Subsystems (ECLSS) and Extravehicular Activity (EVA) systems suitable for STS and other advanced needs.

Environmental Effects Analysis - manage efforts to develop the data base and conduct analyses to ascertain any environmental impact of STS operations.

Supporting Technology Advanced Developments - development of prototypes, long lead time systems and new procedures and software for advanced systems.

Advanced Missions - manage studies to define advanced transportation and orbital systems.

Life Sciences:

Medical Research - establish human baseline data, investigate and develop countermeasures to solve space medicine problems, and develop information techniques and equipment to support medical operation and medical experiments.

Food Systems Technology - develop nutritional requirements and food processing systems in support of human space flight.

Spacelab Payload - development of Spacelab life sciences research capability through common operating research equipment development; definition and development of in-flight biomedical experiments.

Lunar and Planetary Geosciences - develop and maintain technical discipline base for lunar and planetary geosciences and planetary materials handling techniques.

Technology Experiments in Space - manage the Orbiter experiments program; definition and development of experiments in areas consistent with other JSC space roles.

Remote Sensing - Testing spaceborne instruments used to measure various phenomena on or above the Earth from space. Includes development of techniques to process and understand the data received and to use it.

SUMMARY OF RESOURCES REQUIREMENTS

Funding Plan by Function

(Thousands of Dollars)

		1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
I.	Personnel and Related Costs..................	155,283	155,988	156,506	157,729
II.	Travel.......................................	4,756	4,963	4,808	5,350
III.	Operation of Installation....................	54,772	59,452	48,673	55,031
	A. Facilities Services......................	(27,912)	(33,911)	(28,990)	(32,767)
	B. Technical Services.......................	(8,521)	(8,916)	(7,983)	(8,560)
	C. Management and Operations................	(18,339)	(16,625)	(11,700)	(13,704)
	Total, fund requirements..............	214,811	220,403	209,987	218,110

DISTRIBUTION OF PERMANENT WORKYEARS BY PROGRAM

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
RESEARCH AND DEVELOPMENT	1,168	1,319	1,470	1,565
Space Station	422	620	714	815
Space Transportation Capability Development	530	489	572	563
Space Science and Applications	181	146	141	142
Physics and Astromony	24	0	25	25
Life Sciences	117	85	76	73
Planetary Exploration	33	31	33	33
Space Applications	7	30	7	11
Commercial Programs	2	6	7	6
Technology Utilization	1	1	2	1
Commercial Use of Space	1	5	5	5
Aeronautics and Space Technology	33	58	36	39
Aeronautical	0	5	1	1
Space	33	53	35	38
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	1,550	1,394	1,313	1,219
Shuttle Production and Operations Capability	417	388	409	363
Space Transportation Operations	1,133	1,006	904	856
Total, direct workyears	2,718	2,713	2,783	2,784
CENTER MANAGEMENT AND OPERATIONS SUPPORT	529	488	469	469
Total, Full-time workyears	3,247	3,201	3,252	3,253
Other than Full-time	130	100	90	89
Total, workyears	3,377	3,301	3,342	3,342

PROGRAM DESCRIPTION

	Permanent Civil Service Workyears
RESEARCH AND DEVELOPMENT	
SPACE STATION..	815

The fiscal year 1987 staffing provides for the necessary management activities to support the Space Station through the program definiton phase and initial development efforts for which JSC is responsible. It also provides for the continuing effort required in systems engineering and integration (SE&I), advanced technology development, focused technology, utilization, and operational readiness necessary to provide products to the definition and preliminary design contractors.

The Space Station program requires a coordinated effort across disciplines to insure that all functions are adequately addressed in the definition phase. NASA has made a commitment to undertake the SE&I of the total Space Station with civil servants, whereas on past programs, a majority of this effort was performed by contractors. This is necessary due to the lack of precedent for coordinating such a highly complex array of systems and sub-systems with the varied and intricate organizational structures involved in this program. SE&I products will provide the capability for simulations of docking and berthing, on-orbit assembly of large structures, total on-orbit operational simulations, integration of various elements such as the Space Transportation System (STS), Orbit Maneuvering Vehicle/Orbital Transfer Vehicle (OMV/OTV) and the systems, manipulators, extra-vehicular activity (EVA), human productivity, and applications software as well as management of the definition efforts pertaining to the overall structures and architecture of the Space Station systems, outfitting of the habitation module, definition of the EVA requirements, thermal management, mechanisms, airlock, data management, communications and tracking. In addition, JSC is responsible for the overall resources integration and analysis of all these efforts.

Utilization efforts will continue to develop and identify potential users and define functional and user requirements based on the payload needs for science, commercial and technology development missions, which will drive the design of the overall Space Station systems capabilities to provide user friendly and cost effective services.

Operational readiness of the Space Station will be dependent on the systems developed to support ground and on-orbit requirements. The integration of technical and user requirements to support long-term systems functions necessitate the beginning of operational readiness early in the life of the Space Station.

Crew involvement in the definition process provides insight into future payload operations on the Space Station as will defining Station and STS interfaces.

	Permanent Civil Service Workyears
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT................................	563

The support of the Spacelab development effort includes establishing and controlling Shuttle interface with the Spacelab for overall safety requirements for the Shuttle/Spacelab, and support of the Marshall Space Flight Center in the performance of its assigned responsibilities. JSC is responsible for crew mission training in conjunction with flight hardware and the development and operation of Shuttle/Spacelab simulators and trainers, as well as Spacelab support resident in the Orbiter general purpose computer.

Payload integration activities involve both the upper stages project and the tethered satellite system. For the upper stages, duties include the efforts necessary to integrate the interface between the Orbiter and the payload. JSC is involved with planning the integration of the Interim Upper Stage, the Centaur G and G prime, the Transfer Orbit Stage, and the Payload Assist Module. JSC provides the support of payload-unique integration requirements to the Tethered Satellite System.

Payloads operations and support equipment provide optional services for payloads. These efforts involve performing analytical tasks for the payloads that require special analysis, and the building of modification of hardware for unique payloads, hardware that supports specific classes of payloads, or hardware that provides interfaces between the payload and the Orbiter.

The advanced programs activities at JSC are planned and administered to support current and future Agency programs. Major activities at JSC are designed to promote more efficient operations of the STS and emphasis has been placed on developing and enhancing satellite services to improve utilization of the Orbiter vehicle. Support to the development of upper stages and the integration of payloads have been and will continue to be major tasks of interest. Supporting technology activities are conducted to advance the use of artificial intelligence and its applications in pursuance of NASA's goals.

Permanent Civil
Service Workyears

SPACE SCIENCE AND APPLICATIONS

PHYSICS AND ASTRONOMY.. 25

JSC has the role of mission manager for the Spacelab flights, and of providing mission support. This includes the integration of all physics and astronomy experiments that are placed in the Spacelab modules, pallets, and in the mid-deck. JSC integrates the experiments into other Spacelab pallets, such as the OAST Multi Purpose Experiment Structure (MPES) Pallet and the large format camera. In some cases, JSC also designs and develops the individual experiments to be used on the missions.

LIFE SCIENCES.. 73

The Center has the lead role in evaluating human physiological changes associated with the space environment and providing effective countermeasures to assure crew health and optimal performance, e.g., the Space Adaption Syndrome (SAS) activity which focuses on investigating the potential problems the Space Shuttle crew have in adjusting to the weightless environment of space. These experiments are also designed to utilize the space environment to accomplish medical and biological research.

PLANETARY EXPLORATION... 33

The Center supports the Agency's planetary exploration program in the area of geosciences where a strong, active research group is required to support future programs, provide curatorial support, assist in information dissemination and interact with outside scientists. To provide this support, the research group pursues research on the compositions, structures and evolutionary histories of the solid bodies of the solar system. The Center has an ongoing program of analysis of planetary materials and of remote sensing data, a theoretical studies program and a program which is involved in the development of remote sensing instrumentation. The definition of geoscience requirements for future planetary flight missions involves extensive interaction with the planetary science community.

SPACE APPLICATIONS.. 11

Space applications flight projects responsibilities at JSC center around Shuttle payload instrument development. Responding to airborne measurement requirements, JSC is also developing and implementing an aircraft sensors plan involving testing, maintenance, and operation of a wide variety of report sensors to provide data to investigators. JSC is assigned mission management responsibilities for the Earthward-looking remote sensing Shuttle missions SRL-2 and SRL-3. This includes the mission planning, real-time mission control, mission requirements definition, and experiment integration.

Permanent Civil
Service Workyears

COMMERCIAL PROGRAMS

TECHNOLOGY UTILIZATION.. 1

The Technology Utilization program transfers new knowledge and innovative technology resulting from NASA's research and development programs for application by the private and public sector.

COMMERCIAL USE OF SPACE... 5

The objective of Commercial Use of Space program is to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology space-based research and development. This effort will establish an organizational focal point to initiate a program specifically intended to foster commercial use of and access to space.

AERONAUTICS AND SPACE TECHNOLOGY

AERONAUTICAL RESEARCH AND TECHNOLOGY....................................... 1

The Center is continuing its joint effort with the Langley Research Center on a study for the development of Advanced Information Processing Systems (AIPS) architecture which will provide the highly reliable redundancy management required in distributed processing systems of future aircraft and space flight control systems.

SPACE RESEARCH AND TECHNOLOGY.. 38

JSC is undertaking the study of a family of technologies for space station subsystems and improved STS operations. The technologies include: improvement of man-machine interactions in space, advanced thermal concepts, evaluation of ADA language in NASA flight systems, environmentally controlled life support systems efficiencies, development of docking/berthing systems required for large space systems, data system architecture designs, and methodologies to improve cost effectiveness of guidance, navigation and control (GN&C) systems. In addition, space research and technology activities include space energy conversion, space flight systems, materials and structures and systems analysis.

	Permanent Civil Service Workyears
SPACE FLIGHT, CONTROL, AND DATA COMMUNICATIONS	
SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY..............................	363

Activities consistent with the launch schedule and procurement of necessary flight and ground support equipment will be continued. The National Space Transportation System Program Office of JSC has program management responsibility for program control, overall systems engineering, and Space Shuttle system integration. Management of the "lead center" functions as related to the Space Shuttle and overall management of the production of the orbiter system is provided. This includes management of various orbiter systems (e.g., structures, propulsion, power, avionics, etc.) and to lower selected elements within the subsystems. Sustaining engineering for individual subsystems (line replaceable units such as the fuel cells and remote manipulator) of operational flight hardware will begin transitioning to the Kennedy Space Center during 1986. JSC is responsible for management of a relatively large quantity of supporting equipment. Examples of such equipment are: extra-vehicular mobility unit, closed circuit television, survival radio sets, dosimetry, crew equipment, photographic camera systems, and bioinstrumentation.

To integrate all vehicle systems into an efficient operating system, many detailed interfaces and functional performance features must be identified and defined. Specific interface control documents are identified and established, including both flight systems and flight to ground system. General capability and performance criteria are established for special areas of consideration such as electromagnetic compatibility and lightning protection. Systems operations require the preparation of systems performance data and operations information.

Since the Orbiter represents an integrated complex of technical and engineering disciplines, specific subtasks have been assigned to a variety of technical organizations at JSC. Included in these tasks are: providing technical expertise in the Orbiter life support systems; performing engineering analysis and performance evaluation for communication and tracking systems ground testing; providing expertise in guidance, navigation, control, instrumentation and electrical power distribution; analysis of vehicle attachment and separation systems; analysis of total Shuttle systems, Shuttle/payload interface, crew station evaluation, and engineering analysis to determine overall vehicle performance characteristics in the area of aerodynamic performance, flight characteristics, performance, and dynamics including aeroelasticity.

The successful flight and operational performance of the Space Shuttle is dependent on the proper functioning of integrated electronic equipment. Collectively, these are termed the Integrated Avionics System. Avionics provides the Shuttle pilots and crew with the total assessment and command capability necessary to fly, and operate the vehicle. Because of the critical nature of this system, very close attention is given to the identification of performance requirements and integrated performance.

A variety of avionic elements are included within the Space Shuttle system, each of which requires the attention of a group of technical experts. These elements include: guidance, navigation and control, data processing, communication and tracking, instrumentation, displays and control, solid rocket booster interface, electrical power distribution and control, and external tank instrumentation interface.

	Permanent Civil Service Workyears
SPACE TRANSPORTATION OPERATIONS...	856

Space transportation operations staffing provides for Shuttle operational flight program management including vehicle system integration; Mission Control Center (MCC) operations; crew equipment and crew training; flight mission planning and operations; and procurement of orbiter flight spares and hardware. The management and procurement of orbiter flight spares will transition to Kennedy Space Center during 1986.

Mission flight support includes a wide variety of planning activities ranging from operational concepts and techniques to detailed systems operational procedures and checklists. Tasks include preparation of development system and software handbooks, flight rules, detailed crew activity plans and procedures, development of MCC and network systems requirements, and operations input to the planning for the selection and operation of Shuttle payloads.

Operations flight design includes: the identification of operational requirements for the design of planned and improved spacecraft systems; the development of flight techniques for utilization of these systems; and the development of nominal and contingency flight profiles for all Shuttle missions. This covers conceptual level profile development and analysis, beginning about two years before the flight, and operational profile development and analysis, accomplished immediately prior to the flight. The software activities for operational flights also include the continued development, definition, and verification support of the guidance, targeting, and navigation systems software requirements of the Orbiter and MCC. Software changes for Orbiter improvements will upgrade vehicle capabilities and performance.

Specific flight planning activity encompasses the flight design, flight analysis, and software activities. The flight design tasks include supporting the crew training simulations and development of flight techniques. Flight design products include conceptual flight profiles and operational flight profiles which are issued for each flight. The software activities include the development, formulation, and verification support for the guidance, targeting, and navigation systems software requirements in the Orbiter and MCC. In addition, the flight dependent data co-located in the eraseable memory (mission-to-mission changes) is developed from the flight design process for incorporation into the Orbiter software and MCC systems.

Avionics and software testing and checkout in the Electronics Systems Test Laboratory and the Shuttle Avionics Integration Laboratory will continue. The purpose of these laboratories is to verify the functional performance of the Shuttle Integrated Avionics Systems, validate the system design, and verify compatibility of the various radio frequency communication links.

Orbiter avionics software development will provide payload support. This will include general capabilities for Spacelab and Upper Stages, with flexibility available to implement specific payload requirements as optional services.

Reconfiguration tools (hardware and software systems) to permit support of the high flight rates are being implemented in the Shuttle Mission Simulator complex and procedures training facility. The capability for near-continuous training of a number of flight crews for different types of missions with different payload requirements and on different Orbiters requires management and utilization of a very high volume of data. Therefore, automated tools are essential to support this pace of training. In addition, simulator system upgrades must be continuously being made to keep up with changes to the Orbiter.

Furthermore, there is provision for rapid handling of mission-to-mission software changes (flight dependent data in eraseable memory) and associated verification on a "near production line" basis because of the greater mission rates. To accommodate the production-line type of work, emphasis is being place on software tools and the associated automatic data processing equipment hardware to support the Software Production Facility.

	Permanent Civil Service Workyears
CENTER MANAGEMENT AND OPERATIONS SUPPORT..................................	469

Center Management and Operations Support is provided to all JSC organizations which cannot be identified exclusively to a single program or project. The civil service personnel involved in this support include the following:

Director and Staff - The Center Director, Deputy Director and immediate staff, e.g, Comptroller, Legal, Personnel, Equal Opportunity, Technical Planning, and Public Affairs.

Management Support - Those who will provide information and control service supporting all levels of Center management, both program and functional. Specific functions include resources and financial management, program control, contracting and procurement, property management, and management systems and analysis.

Operations Support - Those who manage or provide for the operation and maintenance of institutional facilities, buildings, systems, and equipment, including those who provide technical services such as automatic data processing, reliability and quality assurance, medical care, and photographic support.

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
I. PERSONNEL AND RELATED COSTS....................	155,283	155,988	156,506	157,729

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Compensation and Benefits				
1. Compensation				
a. Full-time permanent......................	129,042	130,309	130,517	129,006
b. Other than full-time permanent..........	2,301	1,937	1,763	1,748
c. Reimbursable detailees..................	3,813	3,853	4,186	5,957
d. Overtime and other compensation.........	2,797	2,783	2,931	3,182
Subtotal, Compensation..................	137,953	138,882	139,397	139,893
2. Benefits....................................	15,468	15,862	15,713	15,913
Subtotal, Compensation and Benefits.....	153,421	154,744	155,110	155,806
B. Supporting Costs				
1. Transfer of personnel......................	960	409	401	623
2. Personnel training.........................	902	835	995	1,300
Subtotal, Supporting Costs..............	1,862	1,244	1,396	1,923
Total, Personnel and Related Costs	155,283	155,988	156,506	157,729

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
A. Compensation and Benefits	153,421	154,744	155,110	155,806
1. Compensation	137,953	138,882	139,397	139,893
a. Full-time permanent	129,042	130,309	130,517	129,006

The current estimate for 1986 reflects a change from the 1986 budget estimate due to the 1985 pay raise, cost increases associated with career advances.

Basis of Cost for Full-time Workyears

In 1987, the cost of full-time workyears will be $129,006,000.

Cost of full-time workyears in 1986		130,517
Cost increases in 1987		
Within grade and career advances		2,368
Full year cost of 1986 actions	1,199	
Part year cost of 1987 actions	1,169	
Cost decreases in 1987		-3,879
Full year effect of 1986 turnover savings	-2,581	
Part year effect of 1987 turnover	-1,298	
Cost of full-time permanent workyears in 1987		129,006

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
b. Other than full-time permanent				
1. Cost	2,301	1,858	1,763	1,748
2. Workyears	173	144	136	135

The distribution of 1986 workyears is as follows:

Distribution of Other than Full-Time Workyears

Program	Workyears
Development programs	78
Summer programs	0
Other temporary programs	11
Youth Opportunity Programs	46
Total	135

The reductions from the 1986 budget estimate and 1986 to 1987 are the result of a decrease in FTEs.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
c. Reimbursable detailees	3,813	3,853	4,186	5,957

The miliary personnel detailed to the Johnson Space Center on a reimbursable basis are individuals experienced in manned space flight and related fields. Each individual performs a function essential and critical to current and future programs. The increase from the 1986 budget estimate to the 1986 current estimate is due to a revision of reimbursable rates plus the increase of one detailee. FY 1987 is higher due to the inclusion of additional military retirement costs in the rates, plus one additional detailee.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
d. Overtime and other compensation.........	2,797	2,783	2,931	3,182

Overtime in 1987 will be used primarily in support of Shuttle flights; e.g., crew training, trajectory optimization, data reduction integration laboratory, and related support activities. The increase from the 1986 estimate to the 1986 current estimate reflects 1985 experience and the increased Shuttle flight rate. The increase in 1987 is likewise attributed to the increased Shuttle flight rate.

2. Benefits..................................	15,468	15,862	15,713	15,913

The following are the amounts of contribution by category:

Civil Service Retirement Fund...........	9,060	9,078	9,164	9,168
Employee Life Insurance.................	309	346	311	314
Employee Health Insurance...............	3,511	3,752	3,532	3,528
Workman's Compensation..................	633	609	675	675
FICA....................................	482	624	541	738
Medicare................................	1,435	1,431	1,452	1,452
Other benefits..........................	38	22	38	38
Total...................................	15,468	15,862	15,713	15,913

The changes from the 1986 budget estimate to the 1986 current estimates are due primarily to increased contributions to Civil Service retirement and Medicare based on the mix between permanent and non-permanent personnel. The increase in 1987 is due almost exclusively to social security contributions FICA for employees new to the Government system who do not contribute to Civil Service retirement.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
B. Supporting Costs	1,862	1,244	1,396	1,923
1. Transfer of Personnel	960	409	401	623

The transfer of personnel includes movement of household goods, subsistence and temporary expenses, real estate and miscellaneous moving expenses related to change of duty stations. The increase from the 1986 budget to FY 1987 reflects expected increases in the number of accessions.

2. Personnel Training	902	835	995	1,300

The purpose of the JSC training program is to continue to develop the skills and knowledge of civil service employees in order to maintain a state-of-the-art technology to more efficiently support JSC roles and missions. The change from the 1986 budget estimate to the 1986 current estimate reflects a small increase in the level of training, as well as an increase in projected tuituion and other costs. The 1987 change reflects increases in nearly all training categories.

	1985 Actual	1986 Budget Estimate	 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
II. TRAVEL	4,756	4,963	4,808	5,350

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	 Current Estimate	1987 Budget Estimate
A. Program Travel	3,863	3,933	3,879	4,373
B. Scientific and Technical Development Travel	351	507	370	390
C. Management and Operations Travel	542	523	559	587
Total, Travel	4,756	4,963	4,808	5,350

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
A. Program Travel	3,863	3,933	3,879	4,373

Program Travel is specifically required for the accomplishment of the Center's mission and accounts for approximately 82 percent of the travel budget for 1987. The 1986 and 1987 travel supports the planned increase of support to Space Station activities. All other program travel remains unchanged. Travel is required to support operations activity including launch, mission support, coordination of engineering and technical activities, and support of payload technical integration. The 1986 current estimate reflects reductions based on actuals for 1985 and approximately the same requirement level. The 1987 estimate reflects expected increases in transportation costs and increases in Space Station requirements.

B. Scientific and Technical Development Travel	351	507	370	390

Scientific and technical development travel permits employees to participate in meetings and technical seminars with other representatives of the aerospace community. The reduction to the current estimate reflects lower requirements than previously expected. The increase in 1987 is for increased transportation costs.

C. Management and Operations Travel	542	523	559	587

Management and operations travel is used for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, and procurement activities; travel of the Center's top management to NASA Headquarters and other NASA Centers; and local transportation. The increases from the 1986 budget estimate to the 1986 current estimate and 1987 reflect nominal airfare escalation.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
III. OPERATION OF INSTALLATION....................	54,772	59,452	48,673	55,031

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Facilities Services............................	27,912	33,911	28,990	32,767
B. Technical Services.............................	8,521	8,916	7,983	8,560
C. Management and Operations......................	18,339	16,625	11,700	13,704
Total, Operation of Installation............	54,772	59,452	48,673	55,031

Explanation of Fund Requirements

Operation of Installation provides a broad range of services, supplies, and equipment in support of the Center's institutional activities. These are divided into three major functional areas: Facilities Services, the cost of maintaining and repairing institutional facilities and equipment, and the cost of custodial services and utilities; Technical Services, the cost of automatic data processing for management activities; and the cost of educational and informational programs and technical shops supporting institutional activities; and Management and Operations, the cost of administrative communications, printing, transportation, medical, supply, and related services.

The change from the 1986 budget estimate to the 1986 current estimate is primarily due to realignment of support contractor obligation plans, delays and deferrals in provision of goods and services to accommodate the reduction in the overall NASA R&PM appropriation and changes in communications and logistics cost allocations to portray more accurately the cost of these services, along with a decrease in anticipated utility costs. The increase in 1987 is due to estimated contractor wage escalation, utilities consumption and rates, expected price levels for other goods and services, and the full year funding of support service contracts.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
A. **FACILITIES SERVICES**	27,912	33,911	28,990	32,767

This physical plant supports an average daily on-site population of approximately 8,200 personnel plus an additional 3,000 personnel located at nearby facilities and Ellington Air Force Base. These budget estimates also include resources associated with the physical plant requirements of the White Sands Test Facility and for facilities used at Ellington Air Force Base.

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Maintenance and Related Services	9,397	11,368	8,530	10,987
2. Custodial Services	5,374	5,687	5,779	6,070
3. Utility Services	13,141	16,856	14,681	15,710
Total, Facilities Services	27,912	33,911	28,990	32,767

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Maintenance and Related Services	9,397	11,368	8,530	10,987

This activity involves routine maintenance and facilities support for JSC at Houston, as well as White Sands Test Facility and Ellington Air Force Base, and includes such activities as support for utility systems; administrative office alterations and painting; ground maintenance; and other facility and system design and modification tasks.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		

The decrease from the 1986 budget estimate to the 1986 current estimate is the result of less than full year obligations of support service contract, and an overall reduction and deferral in facility maintenance and equipment replacement due to budget reductions. The increase in 1987 is due to contractor rate escalation, replacement of equipment and the full year funding of support service contracts.

2. Custodial Services..........................	5,374	5,687	5,779	6,070

This activity involves support contractor effort at JSC to provide security guard services such as protection of government facilities, equipment, and classified information and badging for all on-site personnel and official visitors; janitorial services (including highly specialized cleanroom services); and fire protection services such as maintenance of alarms and fixed fire fighting equipment, and industrial safety and inspection. The increase from the 1986 budget estimate to the 1986 current estimate reflects current support service contractor wage rates. The increase in 1987 is due to escalation in contractor rates.

3. Utility Services............................	13,141	16,856	14,681	15,710

This category includes purchased utilities and support contractor effort for the operation and maintenance of the utility distribution system. The increase from the 1985 actual to the 1986 current estimate is the result of increased consumption due to occupancy of the modular office buildings that are to be completed in the second quarter of FY 1986. The net decrease from the 1986 budget estimate to the 1986 current estimate is due to lower utility cost rate based on 1985 experience offset by a higher expected utility consumption in 1986. The increase in 1987 is due to increased consumption to support planned Shuttle training and flight requirements, and the full year funding of support service contracts.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands	of Dollars)	
B. TECHNICAL SERVICES	8,521	8,916	7,983	8,560

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing	4,969	4,955	4,560	4,912
a. Equipment	0	595	452	480
b. Operations	4,969	4,360	4,108	4,432
2. Scientific and Technical Information	2,574	2,810	2,510	2,688
3. Shop and Support Services	978	1,151	913	960
Total, Technical Services	8,521	8,916	7,983	8,560

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing	4,969	4,955	4,560	4,912

This activity provides support to all JSC administrative ADP functions; included within this area are institutional portions of lease and maintenance costs of hardware systems within the Central Computer Facility, as well as contractor effort for computer programming, operations, keypunch, and other support personnel. The ADP systems supported include institutional management, finance and accounting, procurement, contract status and tracking, personnel management, and utility tracking than previously anticipated. The decrease from the 1986 budget estimate to the 1986 current estimate is due to lower than estimated support service contractor wage rate increases in 1986, and a rephasing of contract obligation plans. The 1987 increase reflects estimated support contractor rates for the contractor workforce needed to operate the administrative ADP systems and a full year funding of these contracts.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands	of Dollars)	
2. Scientific and Technical Information........	2,574	2,810	2,510	2,688

This activity provides for a public affairs educational and informational program and support to the Center in provision of various scientific and technical information services. Included in the public affairs program are: motion picture production from script to screen; film clip preparation; exhibit management and refurbishment; visitor orientation tours; lecturing; mail answering service; and other public affairs activities. The decrease from the 1986 budget estimate to the 1986 current estimate is due to lower than estimated support service contractor wage rate increases in 1986, and a rephasing of contract obligation plans. The increase in 1987 reflects expected contract rate increases.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
3. Shop and Support Services..................	978	1,151	913	960

These funds provide for a support contractor who provides JSC graphics and photographic services. Graphic materials are prepared for use in presentations and senior management reviews. Various kinds of films are processed and reproductions and reprints made. The decrease from the 1986 budget to the 1986 current estimate is due to reduction in contractor workyears. The increase in 1987 is due to contractor rate increase.

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
	(Thousands of Dollars)			
C. MANAGEMENT AND OPERATIONS	18,339	16,625	11,700	13,704
1. Administrative Communications	6,494	5,122	2,498	3,026
2. Printing and Reproduction	180	259	217	230
3. Transportation	2,521	2,566	2,160	2,283
4. Installation Common Services	9,144	8,678	6,825	8,165
Total, Management and Operations	18,339	16,625	11,700	13,704

Explanation of Fund Requirements

1. Administrative Communications	6,494	5,122	2,498	3,026

Communications support for JSC and WSTF consists of local and long distance telephone service and other communications services. Local service includes Centrex lines and telephones at JSC and WSTF. Long distance service includes the cost for FTS, commercial toll calls, and a small number of dedicated voice circuits. Other communications services include teletype and wire news services; the operation and maintenance of a closed circuit TV system; and local radio networks for fire, security and custodial uses.

The reduction from the 1986 budget to the 1986 current estimate is due to the realignment of the funding of the Central Telecommunications System to reflect actual usage and the increased impact of data transmission. The change in 1987 is for an estimated rate increase.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Printing and Reproduction..................	180	259	217	230

Printing services are provided by on-site and off-site facilities. The on-site printing plant, operated by JSC personnel, produces approximately 60 million units each year. In addition to this on-site printing plant, JSC also purchases printing from private firms through Government Printing Office contracts, about 52,000,000 units each year. Purchased printing is overflow requirements that cannot be handled on-site, and printing which requires capabilities not avilable at the on-site plant. The decrease from 1986 budget to the 1986 current estimate is based on actual costs incurred in FY 1985 and anticipated FY 1986 requirements. The increase in 1987 is an increase in supplies and materials costs.

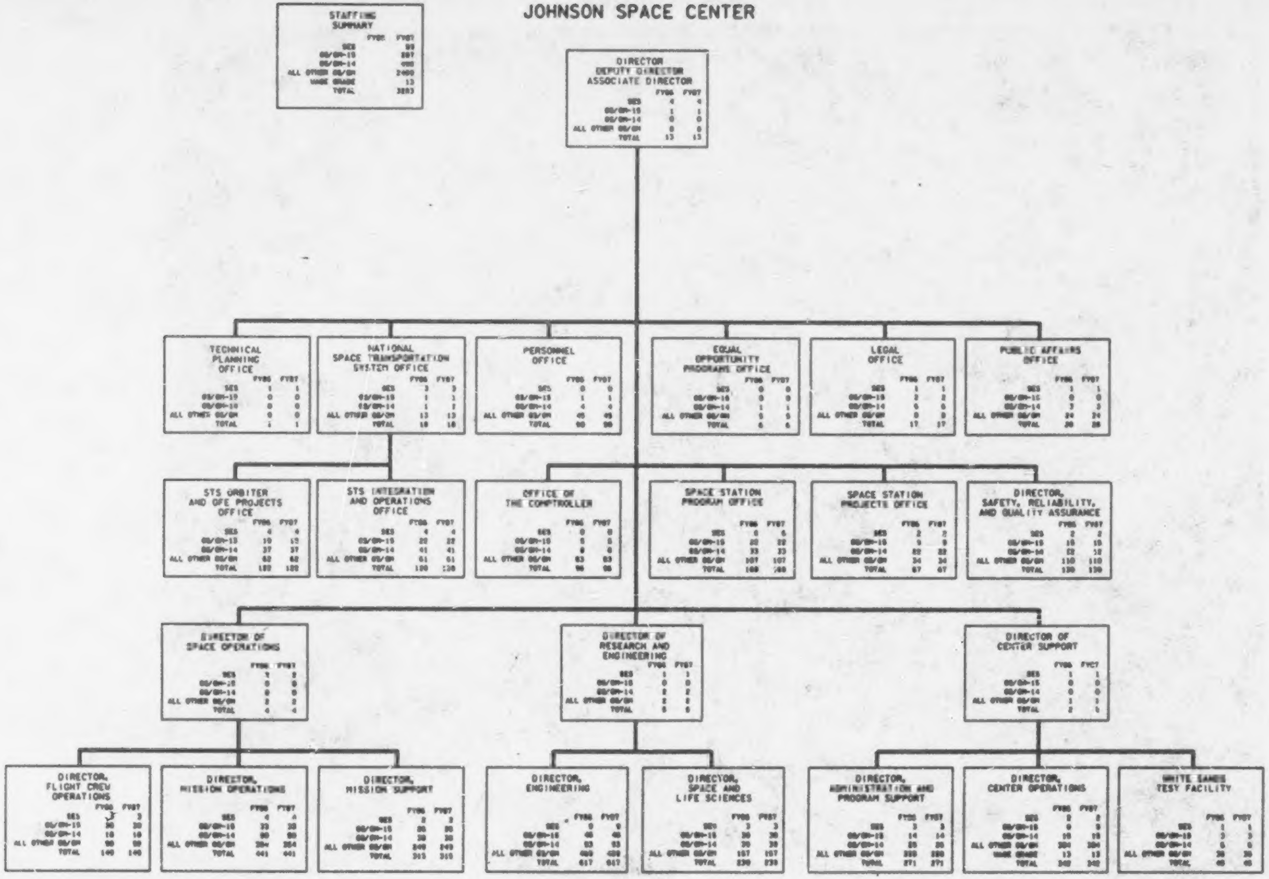
3. Transportation..............................	2,521	2,566	2,160	2,283

Transportation includes administrative aircraft maintenance and fuel costs, lease of passenger vehicles and trucks, including GSA drivers and dispatchers and maintenance of vehicles. The reduction from the 1986 budget to the 1986 current estimate is due to an decrease in administrative aircraft specialized maintenance costs and realignment of truck lease rental costs. The increase in FY 1987 is due to expected increases in vehicle lease, fuel and maintenance costs.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
4. Installation Common Services................	9,144	8,678	6,825	8,165

These services support center management and staff activities, provide medical services, and cover various installation support services. Center management and staff functions include legal, personnel, procurement, and EEO activities. Medical services provided include occupational medicine and environmental health, consisting of the operation of the JSC on-site clinic; emergency assistance at Ellington Field; providing physicals for JSC personnel at Downey, California; medical consultation and crew test support; industrial hygiene; radiological health; and an environmental health laboratory. Installation support services include administrative supplies, materials and equipment at the Center and at White Sands Test Facility; JSC share of operating costs at Ellington Field and miscellaneous administrative support. The decrease from the 1986 budget to the 1986 current estimate is due to a decrease for the purchase of new and repair of existing administrative equipment, the realignment of logistical services, and a realignment in the obligation of support service contracts. The increase in 1987 results from anticipated price levels and the full year funding of support service contracts.

JOHNSON SPACE CENTER


STAFFING SUMMARY
DIRECTOR
DEPUTY DIRECTOR
ASSOCIATE DIRECTOR
TECHNICAL PLANNING OFFICE
NATIONAL SPACE TRANSPORTATION SYSTEM OFFICE
PERSONNEL OFFICE
EQUAL OPPORTUNITY PROGRAMS OFFICE
LEGAL OFFICE
PUBLIC AFFAIRS OFFICE
STS ORBITER AND GFE PROJECTS OFFICE
STS INTEGRATION AND OPERATIONS OFFICE
OFFICE OF THE COMPTROLLER
SPACE STATION PROGRAM OFFICE
SPACE STATION PROJECTS OFFICE
DIRECTOR, SAFETY, RELIABILITY, AND QUALITY ASSURANCE
DIRECTOR OF SPACE OPERATIONS
DIRECTOR OF RESEARCH AND ENGINEERING
DIRECTOR OF CENTER SUPPORT
DIRECTOR, FLIGHT CREW OPERATIONS
DIRECTOR, MISSION OPERATIONS
DIRECTOR, MISSION SUPPORT
DIRECTOR, ENGINEERING
DIRECTOR, SPACE AND LIFE SCIENCES
DIRECTOR, ADMINISTRATION AND PROGRAM SUPPORT
DIRECTOR, CENTER OPERATIONS
WHITE SANDS TEST FACILITY
FY86
FY87
SES
GS/GM-15
GS/GM-14
ALL OTHER GS/GM
WAGE GRADE
TOTAL

Lyndon B. Johnson Space Center
Houston Texas 77058

RPM 1-30

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987 ESTIMATES

JOHN F. KENNEDY SPACE CENTER

DESCRIPTION

The John F. Kennedy Space Center (KSC) is located 50 miles east of Orlando, Florida. The total land and water area occupied by the installation is 139,305 acres. NASA owns 82,943 acres of that total. The remainder is comprised of the Banana River Causeway Easement (271 acres), the Indian River Causeway Easement (296 acres), and Florida-owned submerged lands with Deed of Dedication (55,795 acres).

Space Shuttle flights began at KSC in 1981 and will begin at Vandenberg Air Force Base, California in 1986. Expendable launch vehicle operations are conducted at both the Air Force's Eastern Space and Missile Center, at Cape Canaveral Air Force Station, Florida, and the Western Space and Missile Center at Vandenberg Air Force Base, California, which is located six miles west of Lompoc, California. Activities at Vandenberg are accomplished within a host-tenant agreement with the Air Force.

The NASA capital investment at KSC, Cape Canaveral Air Force Station, and Vandenberg Air Force Base, including fixed assets in progress and contractor-held facilities as of September 30, 1985, was $1,677,523,000.

CENTER ROLES AND MISSIONS

The Launch Operations Center was established at Cape Canaveral, Florida, in July 1962 to serve as the primary NASA center for the test, checkout, and launch of space vehicles. In late 1963, it was named the John F. Kennedy Space Center and in 1964 the Center was relocated to Merritt Island. This site was chosen because of its unique geographical characteristics, climate, local growth capability, accessibility, and availability. The Center has since become the major free world launch site with a unique civil service staff of unparalleled expertise in the test, checkout, and launch of space vehicles and in the design of associated ground support equipment. The technical facilities developed at KSC represent a recognized national resource. The principal roles of the Center are:

Space Transportation System (STS) Ground Operations - includes Space Shuttle launch preparation, launch, landing and refurbishment; Spacelab and Spacelab payloads ground processing; Cargo/experiment integration and processing; upper stages ground processing; and operation and maintenance of ground support equipment. Orbiter sustaining engineering and logistics responsibilities will begin transitioning from the Johnson Space Center during 1986.

Expendable Launch Vehicle Operations - includes launch preparation, checkout and launch for the current inventory of launch vehicles on a reimbursable basis.

Space Station - Space Station effort at KSC will consist of activities in four major areas: utilization, advanced technology development, system engineering and integration, and operational readiness.

SUMMARY OF RESOURECES REQUIREMENTS

FUNDING PLAN BY FUNCTION

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
I. Personnel and Related Costs..................	92,462	94,551	93,999	96,006
II. Travel..	2,510	2,350	2,464	2,870
III. Operation of Installation....................	89,516	96,518	98,237	109,220
A. Facilities Services........................	(50,446)	(58,583)	(59,337)	(65,671)
B. Technical Services.........................	(10,068)	(10,683)	(13,247)	(14,052)
C. Management and Operations.................	(29,002)	(27,252)	(25,653)	(29,497)
Total, Fund Requirements..................	184,488	193,419	194,700	208,096

DISTRIBUTION OF PERMANENT CIVIL SERVICE WORKYEARS BY PROGRAM

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
RESEARCH AND DEVELOPMENT	492	761	601	680
Space Station	65	366	146	244
Space Transportation Capability Development	273	271	312	310
Space Science & Applications	144	114	138	121
Physics & Astronomy	138	108	126	108
Life Sciences	6	6	12	13
Commercial Programs	5	5	5	5
Technology Utilization	2	2	2	2
Commercial Use of Space	3	3	3	3
Space Research and Technology	5	5	-	-
SPACE FLIGHT, CONTROL AND DATA COMMUNCIATIONS	1,062	800	946	862
Shuttle Production and Operational Capability	201	66	116	61
Space Transportation Operations	861	734	830	801
Subtotal, direct	1,554	1,561	1,547	1,542
CENTER MANAGEMENT AND OPERATIONS SUPPORT	510	493	488	488
Total, full-time workyears	2,064	2,054	2,035	2,030
Other than full-time workyears	89	90	82	82
Total, permanent workyears	2,153	2,144	2,117	2,112

PROGRAM DESCRIPTION

Permanent Civil
Service Workyears

RESEARCH AND DEVELOPMENT

SPACE STATION.. 244

Space Station efforts will consist of definition and integration studies and activities in the areas of advanced technology development and operational readiness.

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT................................ 310

The upper stages currently consist of the Inertial Upper Stage (IUS), Centaur, and the Payload Assist Module (PAM). These upper stages are expendable, propulsive stages intended for use in the deployment of Space Shuttle transported payloads to high energy orbits not attainable by the Space Shuttle alone.

The PAM has been developed, checked out and mated to a payload by the commercial developer, McDonnell Douglas. The Center has responsibility for integration of the PAM and its payload into the Shuttle payload bay. KSC is currently engaged in modifying the launch site facilities to accommodate the use of the Centaur as a Shuttle upper stage. These modifications, which affect all major launch facilities and in particular the launch pads and mobile launcher platforms, are planned for completion to support the Galileo and Ulysses missions in 1986.

The Center's role in the Spacelab program is similar to that of the Space Shuttle; that is, KSC is responsible for launch site development and for ground operations leading to the launch. KSC has responsibility for verifying that the Spacelab flight and ground systems are compatible with the Spacelab, with each other, and with safety requirements. During 1985, dedicated Spacelab flights included the second development flight and the first operational flight. The first Spacelab flight unit flew aboard STS-9 in November 1983.

KSC will provide facilities and support to the various customers during processing of their payload. KSC, in concert with other NASA organizations, must analyze potential payload users' requirements and activities. Based on experience gained during the Expendable Launch Vehicle program and thus far in the Shuttle program, KSC will monitor payload activity from conception; participate in design reviews to ensure compatibility with KSC facilities; and provide support coordination during the payload checkout and launch at KSC.

	Permanent Civil Service Workyears
PHYSICS AND ASTRONOMY	108

KSC is responsible for planning and coordinating the integration of the Spacelab experiment with the Spacelab hardware system (Level IV integration). Interfaces are established and maintained with the NASA discipline program offices, the principal investigators, and appropriate engineering groups to assure that scientific objectives of the mission are met.

LIFE SCIENCES	13

KSC will continue its support role in the definition, development and integration of biomedical experiments into Space Shuttle for life sciences research. Included is the responsibility for providing and managing a Life Sciences Principal Investigator Support Facility and assisting in the conduct of life sciences synchronous ground control experiments and procedures required for these payloads. Experiments are designed to use the environment of space to accomplish medical and biological research.

COMMERCIAL PROGRAMS

TECHNOLOGY UTILIZATION	2

The objective of the Technology Utilization program is to encourage the use of and to expedite the application of new NASA technology to private and public sectors outside the Agency.

COMMERCIAL USE OF SPACE	3

The objective of the Commercial Use of Space program is to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology space-based research and development. This effort will establish an organizational focal point to initiate a program specifically intended to foster commercial use of and access to space.

Permanent Civil
Service Workyears

SPACE FLIGHT, CONTROL AND DATA COMMUNCIATIONS

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY............................. 61

With the 1986 initial use of Launch Pad B and Mobile Launch Platform 3, construction of most new launch support facilities and modifications of most existing facilities will be complete. The design, modification or acquisition, installation and checkout of equipment and facilities to be used in support of increased launch rate requirements will continue. This includes equipment provided by KSC contractors, as well as equipment to be supplied by development contractors as part of their flight vehicle responsibilities.

The first Space Shuttle landed at KSC in February 1984. Although installation and checkout of initial operational systems are complete and the ground support equipment installed, there are ongoing new requirements and modifications to existing systems, including the Launch Processing System (LPS).

Support will continue for Launch Pad B construction activities, Launch Complex 39 modifications, and other modifications to facilities or equipment to meet Space Shuttle requirements including modification of existing facilities to support the Centaur upper stage program.

SPACE TRANSPORTATION OPERATIONS... 801

The operations role includes the test and checkout of each flight element as it arrives for flight; the integration of the elements (Orbiter, External Tank, Solid Rocket Boosters and their subsystems) into the Space Shuttle vehicle, and the integrated testing of the stacked configuration, propellant loading, and launch. Subsequent to landing, the Orbiter is refurbished by KSC in preparation for the next mission. KSC is responsible for retrieval and disassembly of the expended Solid Rocket Boosters. The Center will also continue the refurbishment of selected existing support equipment for reuse in the Space Shuttle system. KSC is responsible for the operation and maintenance of worldwide contingency and secondary landing sites and for ferrying the Orbiter back to KSC.

Orbiter Vehicle (OV) 102, used in the orbital flight test program and for the first operational flight, was modified during 1983 at KSC for the initial Spacelab mission flown in November 1983. Orbiter Vehicle 099 arrived at KSC in July 1982; Orbiter Vehicle 103 arrived at Kennedy in late 1983; and Orbiter Vehicle 104 arrived in 1985.

The Center is responsible for the launch preparation, checkout, support coordination during the payload checkout, and launch of the current inventory of expendable launch vehicles. This includes the Atlas

Centaur and Delta vehicles. Launches at both the Eastern Space and Missle Center (ESMC) and Vandenberg Air Force Base (VAFB) are the responsibility of KSC.

CENTER MANAGEMENT AND OPERATIONS SUPPORT.................................... 488

Center Management and Operations Support provides support to all Kennedy Center organizations which cannot be identified exclusively to a single program or project. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director, and the immediate staff, e.g., Legal, Patent Counsel, Equal Opportunity, and Public Affairs.

Management Support - The part of the KSC civil service workforce that provides information and control services supporting all levels of center management, both program and functional. Specific functions include resources and financial management, program control, contracting and procurement, property managment, personnel management, and management systems and analysis.

Operations Support - The part of the KSC civil service workforce that provides for the operational and maintenance of institutional facilities, buildings, systems and equipment, including those who manage or provide technical services such as automatic data processing, reliability and quality assurance, medical care, and photographic support.

RESOURCES REQUIREMENTS BY FUNCTION

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
I. PERSONNEL AND RELATED COSTS....................	92,462	94,551	93,999	96,006
Summary of Fund Requirements				
A. Compensation and Benefits......................	91,337	93,144	92,202	93,517
1. Compensation				
a. Permanent positions....................	77,157	78,640	77,760	78,691
b. Other than full-time permanent positions	1,492	1,533	1,526	1,503
c. Reimbursable detailees..................	87	48	54	85
d. Overtime and other compensation.........	3,053	2,759	3,190	3,468
Subtotal, Compensation.................	81,789	82,980	82,530	83,747
2. Benefits................................	9,548	10,164	9,672	9,770
Subtotal, Compensation and Benefits.....	91,337	93,144	92,202	93,517
B. Supporting Costs				
1. Transfer of personnel....................	422	785	649	1,141
2. Personnel training......................	703	622	1,148	1,348
Subtotal, Supporting Costs............	1,125	1,407	1,797	2,489
Total, Personnel and Related Costs.......	92,462	94,551	93,999	96,006

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
A. Compensation and Benefits	91,337	93,144	92,202	93,517
1. Compensation	81,789	82,980	82,530	83,747
a. Permanent Positions	77,157	78,640	77,760	78,691

The current estimate for 1986 reflects a change from the 1986 budget estimate due to a refinement of the estimates.

Basis of Cost for Permanent Positions

In 1987, the cost of permanent positions will be $78,691,000, an increase of $931,000 over 1986. The increase is calculated as follows:

Cost of Full-time Permanent Workyears in 1986		77,760
Cost increases in 1987:		1,768
Within-grade and career advances:		
Full year cost of 1986 actions	879	
Part year cost of 1987 actions	484	
Change in reimbursements received	405	
Cost decreases in 1987		-837
Turnover savings and abolished positions:		
Full year cost of 1986 actions	-241	
Part year cost of 1987 actions	-596	
Cost of Full-time Permanent Workyears in 1987		78,691

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
b. Other than full-time permanent positions				
(1) Cost...............................	1,492	1,533	1,526	1,503
(2) Workyears..........................	120	121	113	113

The distribution of 1987 workyears is as follows:

Distribution of Other than Full-Time Permanent Workyears

Program	Workyears
Other temporary programs..	76
Youth Opportunity Programs..	31
Summer Program..	6
Total...	113

The increase in costs and the decrease in workyears from the 1986 budget estimate to the 1986 current estimate reflects a change in emphasis in this program. The program is now using fewer, but higher skilled, and therefore higher cost employees.

c. Reimbursable detailees............	87	48	54	60

The military personnel detailed to Kennedy Space Center on a reimbursable basis are in the Shuttle Systems Engineering Office. The increase in the 1986 current estimate over the 1986 budget estimate is due to military pay raises. The 1987 estimate incorporates the cost of military retirement.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
d. Overtime and other compensation	3,053	2,759	3,190	3,468

This item includes primarily overtime, holiday pay, night differential, Sunday premium and incentive awards. Changes are due to increases in the launch schedule.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Benefits	9,548	10,164	9,672	9,770

The following are the amounts of contribution by category:

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Civil Service Retirement Fund	5,649	5,757	5,683	5,712
Employee Life Insurance	213	220	214	215
Employee Health Insurance	2,323	2,321	2,338	2,349
Workmen's Compensation	215	244	282	340
FICA	166	60	170	152
Medicare	923	985	925	930
Other Benefits	59	577	60	72
Total	9,548	10,164	9,672	9,770

The decrease from the 1986 budget estimate to the 1986 current estimate is due to the change in compensation estimates. The increase in 1987 is due to the increases in compensation.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Supporting Costs	1,125	1,407	1,797	2,489
1. Transfer of personnel	422	785	649	1,141

Transfer of personnel includes actual expenses involved in the movement and storage of employee's household goods. The decrease in the 1986 current estimate reflects lower than anticipated relocations. 1987 reflects an increase in the number of anticipated relocations.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Personnel training...........................	703	622	1,148	1,348

The increase in the 1986 current estimate and the 1987 budget estimate is due to a reevaluation of KSC's training needs related to new employees, and the need to upgrade fully the skills of existing civil service personnel.

(Thousands of Dollars)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
II. **TRAVEL**	2,510	2,350	2,464	2,870

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	1,731	1,681	1,858	2,218
B. Scientific and Technical Development Travel	70	213	70	74
C. Management and Operations Travel	709	456	536	578
Total, Travel	2,510	2,350	2,464	2,870

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	1,731	1,681	1,858	2,218

Program travel is directly related to the accomplishment of KSC's mission and accounts for approximately 75 percent of the Center's travel budget. Program travel reflects the continued involvement in launch site operations; the design, manufacturing, and testing of ground system equipment, and construction of facilities; and the activation of systems manufactured at off-site locations.

The increase from the 1986 budget estimate to the 1986 current estimate is due to increased program requirements for the transition of orbiter sustaining engineering and logistics from Johnson Space Center, Kennedy Space Center, Vandenberg Launch Support Resident Office at Vandenberg Air Force Base, and increased procurement activities. The increase in 1987 provides continued launch support for Spacelab and payload flights, Orbiter Sustaining Engineering & Logistics transfer, and Space Station Support.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
B. Scientific and Technical Development Travel.....	70	213	70	74

Scientific and Technical Development Travel permits employees to participate in meetings and technical seminars with other representatives of the aerospace community. This participation allows personnel to benefit from exposure to technological advances outside KSC, as well as to present both accomplishments and problems to associates. Many of the meetings are working panels convened to solve certain problems for the benefit of the government. The decrease in 1986 current estimate from the 1986 budget estimate reflects a reduction based on 1985 actuals. The increase in 1987 reflects anticipated price levels.

C. Management and Operations Travel...............	709	456	536	578

Management and Operations Travel is used for the direction and coordination of general management matters. It includes travel concerning such areas as personnel, financial management, and procurement activities; travel of the Center's top management to NASA Headquarters, and other NASA Centers; and local transportation. Local travel includes personal travel in and around the official station of the employer, including tolls, parking fees, and taxis. Non-NASA travel includes transportation of persons, per diem and other incidental expenses for all non-NASA employees, such as unpaid advisory committee members and preemployment interviews for NASA SES positions. The increase from the 1986 budget estimate to the 1986 current estimates and to the 1987 budget estimate is due to travel support concerning Kennedy Data Management System; an increase in Permanent Change in Station (PCS) for transferees and new hires; and travel for productivity requirements.

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
III. OPERATION OF INSTALLATION	89,516	96,518	98,237	109,220

Summary of Fund Requirements

A. Facilities Services	50,446	58,583	59,337	65,671
B. Technical Services	10,068	10,683	13,247	14,052
C. Management and Operations	29,002	27,252	25,653	29,497
Total, Operation of Installation	89,516	96,518	98,237	109,220

Explanation of Fund Requirement

Operation of Installation provides a broad range of services, supplies, and equipment in support of the Center's institutional activities. These are divided into three major functional areas: Facilities Services, the cost of renting real property, maintaining and repairing institutional facilities and equipment, and the cost of custodial services and utilities; Technical Services, the cost of automatic data processing for management activities, and the cost of educational and informational programs and technical shops supporting institutional activities; and Management and Operations, the cost of administrative communications, printing, transportation, medical, supply, and related services.

The increase in the 1986 estimate from that originally submitted results from the higher than expected contract wage rates, and the more difficult than estimated implementation of the information system integration task, partly offset by a rephasing of contract obligation plans, and by the delay and deferral of the purchase of other goods and services. The increase from the 1986 current estimate to the 1987 budget estimate results from the full year funding of support service contracts and the expected price levels for such contracts, utilities and other goods and services required to operate the Kennedy Space Center.

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
A. FACILITIES SERVICES	50,446	58,583	59,337	65,671

Summary of Fund Requirements

1. Rental of Real Property	0	12	0	0
2. Maintenance and Related Services	5,673	6,233	7,019	7,851
3. Custodial Services	20,198	23,892	24,004	26,508
4. Utility Services	24,575	28,446	28,314	31,312
Total, Facilities Services	50,446	58,583	59,337	65,671

Explanation of Fund Requirements

1. Rental of Real Property	0	12	0	0

This provides for the rental of off-site facilities for news and other media centers for NASA launches. We now provide space for the news and media center on site. The decrease from the 1986 budget estimate to the 1986 current estimate is due to not having to rent off-site facilities.

2. Maintenance and Related Services	5,673	6,233	7,019	7,851

This activity involves the management, supervision, engineering, operation and maintenance required to plan, initiate, and perform services on institutional facilities, systems, and equipment. It includes ground maintenance; the development and implementation of a maintenance program for all institutional government furnished and contractor acquired systems, facilities, and equipment; the operations and maintenance at the Kennedy Vandenberg Resident Office at Vandenberg Air Force Base, CA; and the general management and supervision of the operations and maintenance of the power, lighting, HVAC, water and sewer systems. Also, the contractor will implement and manage energy conservation projects, programs, audits, and inspections on institutional facilities to insure conformance of energy conservation policy and to identify new energy initiatives in such areas as modification, operational changes, energy studies and awareness. These funds also provide materials and equipment needed to support these functional needs.

The increase in 1986 from the budget estimate results from a reestimate of the cost of providing operation and maintenance support for the additional facilities coming on-line last year and this year, partly offset by a rephasing of support service contract obligation plans. The increase in 1987 is due to the full year funding of support service contracts at expected contractor wage rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
3. Custodial Services	20,198	23,892	24,004	26,508

This category includes janitorial services, fire protection, and security. Funding provides janitorial services to highly specialized clean room areas and orbiter support equipment; conducting fire drills and fire inspections of facilities and equipment and fighting fires. Security protection of personnel and property involves: support of hazardous tests and operations; badging of all on-site personnel and official visitors; safeguarding flight hardware and other items of high intrinsic value; protection of classified information; and maintaining area surveillance and traffic control. Other activities in this category consist of pest control services, laundry services, and supplies and equipment used by the support contractor performing the function. The increase from the 1986 budget estimate to the 1986 current estimate is due to higher than expected support costs for new facilities coming on-line in 1985 and 1986, partially offset by the rephasing of support service contract obligation plans, and the delay and deferral of the purchase of other goods and services. The increase in 1987 results from the full year funding of support service contracts at expected price and wage levels.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
4. Utility Services	24,575	28,446	28,314	31,312

The major utility is electrical energy purchased from Florida Power and Light Company through an Air Force contract. Fuel oil is purchased from a local supplier. Steam service is provided by the Air Force. Water services are purchased from the City of Cocoa and sewage treatment is accomplished on-site. Utility plant operations and maintenance and utility distribution systems maintenance are provided by a support contractor and by the Air Force. At the Kennedy Vandenberg Resident Office at Vandenberg Air Force Base, CA., utilities are purchased through the United States Air Force.

The decrease from the 1986 budget estimates to the 1986 current estimate reflects support service contractor wage rates and utility rates not as high as previously anticipated, partially offset by an increase in energy use.

The increase from the 1986 current estimate to the 1987 budget estimate is for anticipated support contractor wage rates, projected purchased utility rates and projected utility consumption for increased launches and support of additional facilities.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
B. TECHNICAL SERVICES............................	10,068	10,683	13,247	14,052

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing..................	7,244	8,645	10,104	10,932
a. Equipment..............................	660	458	600	650
b. Operations.............................	6,584	8,187	9,504	10,282
2. Scientific and Technical Information........	1,100	1,220	1,341	1,220
a. Library................................	715	690	806	852
b. Education and information..............	385	530	535	368
3. Shop and Support Services..................	1,724	818	1,802	1,900
Total, Technical Services................	10,068	10,683	13,247	14,052

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing..................	7,244	8,645	10,104	10,932

The Base Operations contractor provides programming services for payroll, general accounting, supply, procurement, preventive maintenance, contract surveillance, personnel, security, resources and financial management reports and related management information. The contractor also provides for the development and maintenance of general management ADP programs which include the lease, purchase, and maintenance of ADP equipment, and programming and operations services. The increase from the 1986 budget estimate results from higher costs due to the more difficult than estimated implementation of information system integration. At KSC, the Engineering Management Information System, the Integrated Management Information System, the KSC Inventory Management System, and the Configuration Management Data System will be tied together to make greater use of ADP to improve the Center's management effectiveness. The task of integrating and operating these systems was not adequately provided for in the 1986 budget estimate. The increasein 1987 reflects anticipated price levels for goods and services required in this area.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
2. Scientific and Technical Information........	1,100	1,220	1,341	1,220

This funding provides for operation of a technical library at KSC and for technical and administrative documentation services, including support to the public affairs educational and information program.

The Base Operations contractor operates the library facilities, which provide technical and management books and periodicals, and military, federal, and professional society specifications and standards. The contractor also operates an STS and Spacelab documents repository which catalogs, classifies, and indexes documents, and provides document reference and distribution services. Public Affairs support provides for the gathering and dissemination of information about the agency's program to the mass communications media, the general public, and the educational community at the elementary and secondary levels. The increase from the 1986 budget estimate to the 1986 current estimate reflects the one time costs of providing adequate library support commensurate with the needs of the KSC and contractor technical staff. The 1987 estimate reflects continuing services at anticipated price levels for needed goods and services.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
3. Shop and Support Services...................	1,724	818	1,802	1,900

These funds provide for the Eastern Space and Missile Center photographic services for NASA's Public Affairs Office and any other institutional support. These funds also provide for the institutional part of the mishap reporting system. The support contractor also provides the necessary management of a comprehensive safety program. This includes the establishment and development of both short and long-range work plans, emergency plans and schedules in support of KSC base operations. The increase from the 1986 budget estimate to the 1986 current estimate is due to the reassignment of the safety program from the Management and Operations subfunction to this area. The increase from the 1986 current estimate to the 1987 budget estimate is for anticipated support service contractor wage rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
C. MANAGEMENT AND OPERATIONS	29,002	27,252	25,653	29,497

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications	2,983	2,979	3,061	3,217
2. Printing and Reproduction	642	1,017	743	777
3. Transportation	5,304	5,507	4,925	5,246
4. Installation Common Services	20,073	17,749	16,924	20,257
Total, Management and Operations	29,002	27,252	25,653	29,497

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications	2,983	2,979	3,061	3,217

These funds provide for the costs of local telephone service, Federal Telecommunications System (FTS), long distance tolls, and special communication services in support of all NASA civil service and institutional contractor personnel located at KSC, ESMC, and VAFB. NASA contractors and other institutions who conduct official business with KSC are widely dispersed throughout the United States. KSC utilizes FTS and other leased lines to minimize costs. Special services include teletype, wire news services and lease and maintenance of various small electrical/electronic systems such as printers which support major communications systems. The Base Operations Contractor will perform liaison activities for administrative communications systems and equipment which are installed and maintained by others and used by various contractor and government organizations at KSC and ESMC. The contractor also is responsible for performing operation and maintenance activities for other administrative communications systems and equipment and for operation of communications centers at KSC and ESMC. The increase from the 1986 budget estimate to the 1986 current estimate is due to rate increases. The increase from the 1986 current estimate to the 1987 budget estimate reflects anticipated rate changes.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Printing and Reproduction	642	1,017	743	777

This category includes printing services which are performed by the Government Printing Office (GPO) and minor commercial firms contracted by GPO. These items include KSC reproduction, the house organ, the telephone directory, and Public Affairs brochures and miscellaneous launch support material. Also included are printing and copier services at VAFB. The decrease from the 1986 budget estimate to the 1986 current estimate is due to reduced requirements for Government printed paper and forms based on the 1985 actuals. The increase in 1987 is due to anticipated rate changes.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
3. Transportation	5,304	5,507	4,925	5,246

Funding covers the transportation management function, performed by the Base Operations Contractor, which includes coordination, check, inspection, and document control of all shipments, delivery of in-bound shipments, and the operation of heavy transportation equipment. The maintenance of KSC's administrative aircraft is also included, as well as the cost of passenger and cargo type vehicles used by civil service personnel, and supplies, materials, and equipment used by the support contractor performing the function.

The decrease from the 1986 budget estimate to the 1986 current estimate reflects KSC's reassessment of needs in this area. The increase from the 1986 current estimate to the 1987 budget estimate is for anticipated support contractor and vehicle maintenance rate increases. Also, the estimate provides for a major engine overhaul of the KSC Gulfstream I due to FAA regulations.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
4. Installation Common Services	20,073	17,749	16,924	20,257

These funds provide for management and logistics services, mail and distribution services, medical services, and a wide variety of minor contracts for special and one-time services. The Base Operations Contractor provides management for the following areas: procurement, resources, maintenance, logistics, energy, data and information, staffing and training, planning and scheduling, and safety. This includes the estimating, planning, budgeting, authorizing, controlling, accumulating, and reporting of all costs and manpower associated with contract activities; and the necessary management, supervisory, and administrative personnel required to plan, initiate, and perform the services and operations.

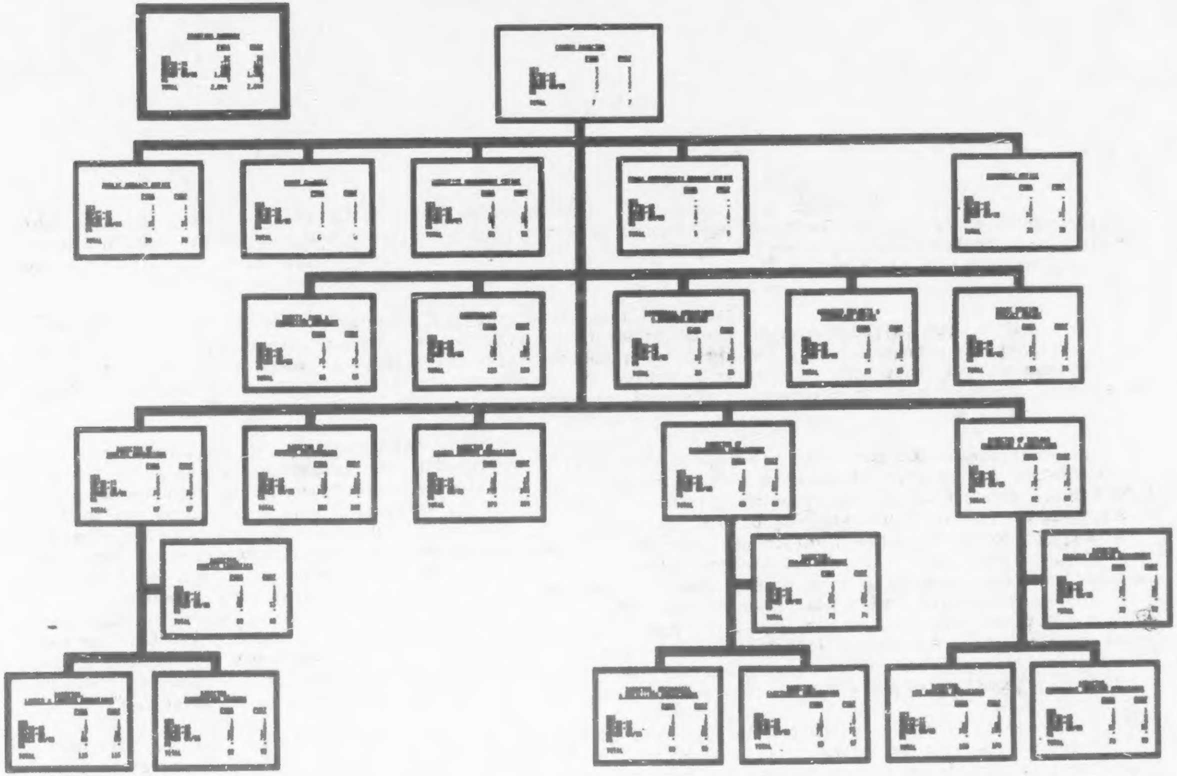
The Base Operations Contractor also provides a broad range of logistics services including receipt, storage, and issue of supplies and equipment as well as maintaining various supply management systems. Mail and distribution services provided by the support contractor include distribution of interoffice mail, classified document control, operation of the KSC branch post office, and postal service charges.

Two major types of medical services are provided, occupational medicine and environmental health. Occupational medicine includes emergency and first aid care for the workforce, guests, and tour visitors; health maintenance and counseling for civil service employees; and a variety of physical examinations and special programs for health maintenance, applied research, and job certification for civil service and contractor personnel. The contractor has also been charged with ensuring compliance with Occupational Safety and Health Administration standards. The medical program operates on a three-shift basis to provide emergency and ambulance services and special standby service in support of launch operations including hazardous tests and operations. Environmental health consists of industrial hygiene, radiological health, and environmental sanitation program elements. This includes: monitoring hypergolic substances and other toxins; the maintenance of a centerwide toxic substances inventory; surveillance of the potable water supply. and distribution; sewage management, sewage treatment and disposal; treatment and disposal of industrial wastes, solid wastes management and disposal; selection and use of pesticides; and the surveillance of sanitation practices in all food services areas.

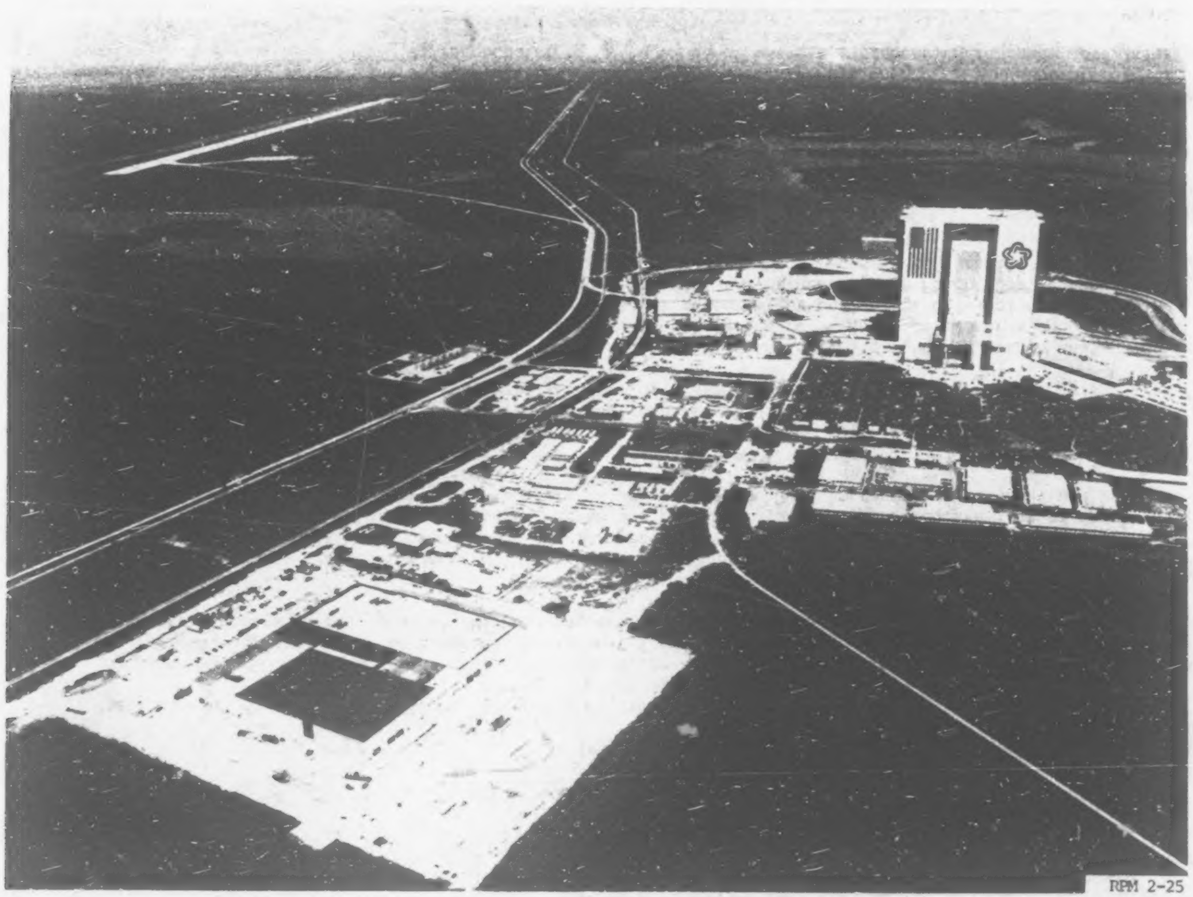
This category also covers lease, maintenance, and purchase of administrative equipment. Rentals are primarily for special purpose office equipment more economical to lease than purchase. Maintenance is provided for all government-owned administrative equipment in active service. Purchases are largely replacements of office machines such as typewriters and calculators. Office supplies and equipment are provided to all civil service and institutional contractor personnel.

The decrease in the 1986 estimate from the budget estimate results from a rephasing of support service contractor obligation plans, the inter subfunction transfer of the safety program, partially offset by higher than estimated support service contractor wage rates. The increase in 1987 is due to the full year funding of support service contracts at anticipated contractor wage rates.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JOHN F. KENNEDY SPACE CENTER



RPM 2-24



RPM 2-25

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987 ESTIMATES

GEORGE C. MARSHALL SPACE FLIGHT CENTER

DESCRIPTION

Operations at Marshall Space Flight Center (MSFC) are conducted at three primary locations.

The principal MSFC site is near Huntsville, Alabama, on Army property at the Redstone Arsenal. The Center occupies 1,841 acres under a non-revocable use permit from the Army. The Huntsville location is connected by deep water access to its component Michoud Assembly Facility via the Tennessee, Ohio, and Mississippi Rivers.

The Michoud Assembly Facility, located 15 miles east of New Orleans, Louisiana, is where the External Tanks for the Space Shuttle are being produced and where activities for other Federal agencies are conducted. The Michoud Facility occupies 832 acres and provides 3,634,344 gross square feet of space, including the main assembly plant. The facility is located on the Gulf Intracoastal Waterway and has deep water access via the Mississippi River.

The Slidell Computer Complex, located at Slidell, Louisiana, 20 miles northeast of the Michoud Assembly Facility, occupies 14 acres and provides centralized computer services for MSFC, Michoud, other NASA Centers, and associated contractors, as well as other government agencies.

A number of individual facilities at MSFC and its component installations are unique within NASA, and the Nation. The combined capability of the science and engineering laboratories, special development facilities, and test facilities provide a unique national resource for designing, developing, and testing large, complex space systems. The total capital investment of the Marshall Space Flight Center and its installations in Louisiana, including fixed assets in progress and contractor-held facilities at various locations as of September 30, 1985, was $836,689,000.

CENTER ROLES AND MISSIONS

The Marshall Space Flight Center serves as one of NASA's primary centers for the design and development of Space Transportation Systems, orbital systems, scientific and applications payloads, and other systems for present and future space exploration. MSFC has the principal role within NASA for large rocket propulsion systems. The Center also has a principal role for the design and development of manned vehicle systems; for Spacelab mission management and payload definition and development; for design and development of large, complex, and specialized automated spacecraft; and management of materials processing in space activities;

for solar and magnetospheric physics; and for astrophysics. MSFC has a primary role within NASA for the development and processing of space science and applications experiments. In addition, MSFC conducts a vigorous research and technology program and is involved in the study and definition of future programs, including significant roles contributing to the development of large, complex space structures, space propulsion systems, materials and engineering, materials processing in space, power systems, guidance and control, fundamental electronics, advanced optical systems, and payload systems analysis and integration.

In addition to on-site activities at Huntsville, Alabama, MSFC manages the Michoud Assembly Facility at New Orleans and the Computer Complex at Slidell, Louisiana. Resident offices are maintained at other centers and in conjunction with major industrial sites in various locations throughout the nation, and in Europe. The principal and supporting roles are:

PRINCIPAL

Propulsion Systems - design, develop and procure propulsion-oriented systems and subsystems. Current focus is on Space Transportation Systems, including Space Shuttle Main Engine, Solid Rocket Booster, External Tank, Orbital Maneuvering Vehicle, Inertial Upper Stage in cooperation with the Air Force, procurement of upper stages for NASA missions and monitoring of commercially developed and produced upper stages such as the Payload Assist Module by McDonnell Douglas and the Transfer Orbit Stage by Orbital Sciences Corp. Advanced program efforts are focused on analysis and definition of propulsion/transportation systems to meet national needs for the next 25 years. The Center has a key role in joint NASA-DOD activities to identify promising systems and to implement technologies to ensure a vigorous national posture in space transportation. This includes propulsion/transportation systems for Space Shuttle replacement, unmanned launch vehicles, heavy-lift launch vehicles, orbit transfer vehicles and propulsion technologies for future high performance systems.

Manned Space Vehicle Development - design, development, and procurement of manned vehicle systems as assigned.

- Spacelab - focus is on program management, systems engineering, development of related payload carriers, procurement, flight and ground operations sustaining engineering, and implementation of a payload operational control center on-site.

- Advanced Development - technology advances focused on advanced missions.

Space Transportation System (STS) Sustaining Engineering - provide sustaining engineering for STS propulsion system hardware and software to assure maintenance of the original design requirements throughout the life of the STS program, decrease the unit cost of manufacturing through design improvements, and upgrade operational performance capabilities through product improvement redesign.

Spacelab Payload Development and Mission Management - management of EASE/ACCESS mission, ASTRO missions, Materials Science Laboratory missions, Earth Observations missions, Spacelab J mission, Sunlab/Dark Sky missions, International Microgravity Laboratory missions, Space Plasma Laboratory missions, Space Technology Experiments Platform mission, and other dedicated and partial payload missions as assigned. Definition and development of payloads, facilities, experiments and instruments for space science and applications missions as assigned.

Specialized Automated Spacecraft - design, development, and procurement of large, complex and/or specialized automated spacecraft as assigned. Current focus is on assembly and verification of the Space Telescope, including science instrument integration and overall systems engineering. Other projects include the Tethered Satellite System in cooperation with Italy's National Research Council, and the Combined Release and Radiation Effects Satellite in cooperation with the U.S. Air Force. Studies are also being conducted on potential future missions such as the Advance X-Ray Astrophysics Facility.

Space Station - completion of space station design and definition studies and initiation of the development of the common module; logistics and laboratory module outfitting; propulsion system, environmental control and life support system, and accommodations for the Orbital Maneuvering Vehicle and the Orbit Transfer Vehicle.

Geostationary Platform Studies - identify and define concepts with associated attached payloads.

Space Processing - development of space processing discipline base, enlistment of user interest in potential applications, and developing and management of space processing experiments and facilities.

Science - engage in space research as necessary to maintain a peer group to act as a focal point for interaction with the scientific community in programs of interest, such as Spacelab, the Advanced X-Ray Astrophysics Facility and the Space Station.

SUPPORTING

Space Structures and Materials - contributing to the development of large, complex space structures and materials technology base; developing and testing technology for advanced optical systems.

Propulsion Technology - developing and evaluating alternate propulsion systems, techniques, and propellants for advanced launch systems and spacecraft.

SUMMARY OF RESOURCES REQUIREMENTS

Funding Plan By Function

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs..................	149,458	151,341	150,523	152,178
II. Travel.......................................	5,075	5,300	5,228	5,670
III. Operation of Installation....................	43,536	45,722	44,344	45,999
A. Facilities Services......................	(20,362)	(22,480)	(21,080)	(22,159)
B. Technical Services.......................	(8,761)	(9,532)	(9,554)	(9,445)
C. Management and Operations................	(14,413)	(13,710)	(13,710)	(14,395)
Total, fund requirements...............	198,069	202,363	200,095	203,847

Distribution of Permanent Civil Service Workyears By Program

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
RESEARCH AND DEVELOPMENT	1,886	2,118	2,088	2,138
Space Station	242	390	360	455
Space Transportation Capability Development	410	423	404	445
Space Science and Applications	1,140	1,138	1,163	1,045
Physics and Astronomy	952	915	988	858
Life Sciences	-	2	-	-
Space Applications	188	221	175	187
Commercial Programs	8	20	25	35
Technology Utilization	7	7	5	5
Commercial Use of Space	1	13	20	30
Aeronautics and Space Technology	86	147	136	158
Aeronautics	-	1	-	-
Space	86	146	136	158
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	855	622	652	607
Shuttle Production and Operational Capability	448	339	342	292
Space Transportation Operations	407	283	298	303
Space & Ground Network Communications & Data Sys.	-	-	12	12
Subtotal, Direct workyears	2,741	2,740	2,740	2,745
CENTER MANAGEMENT AND OPERATIONS SUPPORT	522	489	489	489
Total, Full-Time Workyears	3,263	3,229	3,229	3,234
Other than Full-Time	86	98	90	90
Total, Workyears	3,349	3,327	3,319	3,324

PROGRAM DESCRIPTION

Permanent Civil
Service Workyears

RESEARCH AND DEVELOPMENT

SPACE STATION.. 455

1987 activities include the completion of the definition and preliminary design studies and the initiation of developmental efforts. Advanced technology development, utilization, operational readiness, and systems engineering and integration technology activities will be continued.

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT.................................... 445

Spacelab

Activities include continuation of program management; completion of final deliveries on follow-on production hardware procured from the European Space Agency (ESA) Consortium; integration of ESA and NASA provided hardware and software; and mission integration and preparation of five Spacelab flights, plus other missions involving Spacelab hardware (i.e., Igloo, Pallets, etc.). Also, the development of the capability to fly mixed cargoes will be completed with demonstration missions using Igloo Pallet, Multiplexer De-Multiplexer Pallet, and Hitchhiker configurations.

Inertial Upper Stages (IUS)

Activities involve one IUS/TDRS mission which will require support for (1) A series of readiness reviews conducted to assure the flight readiness of the IUS prior to launch, (2) the conduct of joint integrated flight simulations prior to launch, (3) the launch and flight operations support, and (4) the post flight evaluation of the IUS performance.

Payload Assist Module (PAM)

Activities include technical monitoring of design, development, and production of the PAM-D, PAM-DII, and PAM-A by McDonnell Douglas (the commercial development organization) to insure compatibility in NASA's customer service and marketing activities. A major part of this effort is the Solid Rocket Motor Nozzle Engineering Verification (to provide additional near term insight into existing design and manufacturing processes and their impact on the quality of finished parts) and technology studies (understand processes and material variables and establishment of a material data base). Also perform feasibility studies relative to the utilization of various PAM configurations for future NASA missions.

Tethered Satellite System

Activities include continued technical and programmatic management involving the United States Deployer and instrument development, and overall systems engineering activities for the cooperative effort by the United States and Italy on the Tethered Satellite System. Activities in 1987 will include completion of final assembly and verification of deployer, delivery of the satellite to the prime U.S. contractor, and delivery and integration of the science instruments.

Advanced Programs

The Advanced Programs effort at MSFC includes the definition and implementation of in-house and contracted system studies to establish the fundamental planning and decision making data needed prior to proposing future space programs. Major FY 1987 advanced study activities include: (1) advanced transportation including reusable evolutionary upper stages and shuttle derived launch vehicle systems; (2) platforms and facilities in low-earth and geosynchronous orbit such as tethered satellite systems application and geostationary platform; (3) orbital services such as satellite servicing applications and in-orbit assembly, maintenance and repair; and (4) Shuttle flight demonstrations such as the aeroassist flight experiment.

	Permanent Civil Service Workyears
SPACE SCIENCE AND APPLICATIONS	
PHYSICS AND ASTRONOMY..	858

Hubble Space Telescope

The objective of the Hubble Space Telescope (HST) project is to place in orbit a high quality optical 2.4-meter telescope system by the Space Shuttle for use by the astronomical community in conjunction with NASA. MSFC is the lead center for the management of the Hubble Space Telescope project and has overall implementation responsibility under the Office of Space Science and Applications for meeting cost, schedule, and technical performance of the project. This includes technical assessment and evaluation of contracted activities for system refurbishment. After the HST launch and orbital verification in 1986, the operations phase will be managed/controlled by Goddard Space Flight Center. The total HST project responsibility, including management, operations, and maintenance and refurbishment, will be phased over to the Goddard Space Flight Center by September 30, 1987.

Gamma Ray Observatory

The objective of the Gamma Ray Observatory (GRO) mission is to measure gamma radiation from the universe and to explore the fundamental physical processes powering it. MSFC has responsibility for the design and development of the Burst and Transient Source Experiment (BATSE) which is one of the four experiments being developed to attain the GRO objectives. Hardware fabrication will be completed in 1986 with system testing beginning in late 1986 and completion in early 1987. In 1987 the BATSE hardware will be delivered for GRO integration and test activities at the GRO integration contractor facility.

Spacelab Payload Mission Management

In 1987, MSFC will be responsible for managing the ongoing activities of the Astro missions, Materials Science Laboratory missions, Earth Observations missions, Spacelab J mission, Sunlab/Dark Sky missions, International Microgravity Laboratory missions, Space Plasma Laboratory missions, Space Technology Experiments Platform mission, and other dedicated and partial payload missions as assigned. The Marshall Center is also responsible for definition and development of selected payloads, facilities, experiments, and instruments to be flown on these missions.

Mission management responsibility begins with the definition of the payload complement and ends with the dissemination and analysis of the experiment data and materials resulting from the flight. During 1987, MSFC will continue to manage the assigned mission planning and definition activities, as well as development of the required instruments and supporting hardware and software. Missions scheduled for launch in 1986 include Astro 1, EOM 1/2, and Materials Science Lab missions. Missions scheduled for launch in 1987 include Materials Science Lab Missions, International Microgravity Lab, and Astro 2.

Interfaces will continue to be maintained during 1987 with the appropriate NASA program offices, the Principal Investigators, and other appropriate organizations to assure accomplishment of the scientific objectives of the assigned missions. MSFC will continue to participate in and manage the analysis of the requirements, objectives, and constraints of the STS systems and payload complements in order to develop requirements for all levels of integration to insure physical, functional, and operational compatibility for all assigned missions.

Permanent Civil
Service Workyears

COMMERCIAL USE OF SPACE.. 30

The objective of the Commercial Use of Space program is to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology space and ground-based research and development. This effort established an organizational focal point to initiate a program specifically intended to foster commercial use and access to space.

SPACE RESEARCH AND TECHNOLOGY.. 158

The Space Research and Technology activities are in space energy conversion, controls and guidance, space data and communications, propulsion, aeroassist technology, advanced SSME technology, and systems analysis. The primary effort in 1987 will be on developing technology for future high performance systems and large space systems.

SPACE FLIGHT, CONTROL, AND DATA COMMUNCIATIONS

SHUTTLE PRODUCTION AND OPERATIONAL CAPABILITY.................................. 292

This effort will provide main engines for a national fleet of four Space Shuttle Orbiters; provide sufficient ground support equipment, launch site equipment and support to launch operations; and to establish a logistic support capability to provision spares and repair/overhaul flight hardware. Plans are to continue with the development of additional Shuttle performance capability and the identification of improvements to make space transportation more economical.

SPACE TRANSPORTATION OPERATIONS.. 303

This activity provides the standard operational support services for the Space Shuttle in the operations phase. Primary activities for 1987 will include the production, overhaul, and acquisition of hardware for operational flights. The flight hardware program element provides for the procurement of external tanks (ET), solid rocket motors (SRM), booster hardware, and propellants; spare components for the main engine; and flight hardware elements. Typical functions will be production engineering, manufacturing, sustaining engineering, anomaly resolution, logistics configuration management, systems level analysis, test and integration tasks, ground operations, and contract management.

Permanent Civil
Service Workyears

SPACE AND GROUND NETWORKS 12

MSFC operates the Program Support Communications Network and serves as its major switching control point. This network interconnects by means of leased voice, data and wideband circuits at the NASA centers, Headquarters and major contractor locations for the transfer of programmatic and administrative information.

CENTER MANAGEMENT AND OPERATIONS SUPPORT 489

Center Management and Operations Support is provided to all MSFC organizations and includes the following:

Director and Staff - The Center Director, Deputy Director, and immediate staff, e.g., Comptroller, Administrative Operations, Legal Patent Counsel, Equal Opportunity, Public Affairs, and Safety.

Management Support - Those who provide management and support services to all levels of Center management, both program and functional. Specific functions include resources and financial management, program control, contracting and procurement, property management, personnel management, and management systems and analysis.

Operations Support - Those who manage or provide for the operation and maintenance of institutional facilities, buildings, systems and equipment, including those who manage or provide technical services such as automatic data processing, reliability and quality assurance, medical care, and photographic support.

RESOURCES REQUIREMENTS BY FUNCTION

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
I. **PERSONNEL AND RELATED COSTS**	149,458	151,341	150,523	152,178

Basis of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	128,507	129,220	128,958	129,071
b. Non-permanent	1,463	1,948	1,573	1,573
c. Overtime and other compensation	1,716	2,006	1,953	2,066
Subtotal, Compensation	131,686	133,087	132,484	132,710
2. Benefits	16,321	16,867	16,419	16,821
Subtotal, Compensation and Benefits	148,007	150,041	148,903	149,531
B. Supporting Costs				
1. Transfer of personnel	710	448	736	1,405
2. Personnel training	741	852	884	1,242
Subtotal, Supporting Costs	1,451	1,300	1,620	2,647
Total, Personnel and Related Costs	149,458	151,341	150,523	152,178

Permanent Civil
Service Workyears

SPACE APPLICATIONS.. 187

Microgravity Science and Applications

The Microgravity Science and Applications program emphasizes the fundamental science and technology of processing materials under conditions that allow detailed examination of the constraints imposed by gravitational forces. These studies are directed towards selected materials and processes which will best identify the limitations due to gravity, as well as demonstrate the enhanced control that may be possible by the weightless environment of space. In 1987, MSFC will continue to embody research and development activities in such area as: (1) crystal growth, (2) containerless processing, (3) fluid and chemical processing, and (4) solidification of metals and alloys. Continuing activities include ground based research, engineering and scientific analyses, advanced studies, definition, design, development, and operation of materials processing payloads.

Combined Release and Radiation Effects Satellite (CRRES)

The CRRES activities in 1987 will support a launch in the summer of 1987. These activities include integration of DOD and NASA experiments, integration of the CRRES SRM to the Spacecraft, and System Verification Testing. NASA will perform active experiments in low earth orbit to further its understanding of the Earth's upper atmosphere and ionosphere.

Atmospheric Supporting Research

Theoretical, field, and laboratory experimental research will be conducted in the global weather, severe storms, and local weather areas. Efforts will be concentrated on improving understanding of severe storms, mesoscale and global scale weather systems, and in defining Shuttle free flyer and Space Station missions to obtain data required to understand and predict this phenomena.

COMMERCIAL PROGRAMS

TECHNOLOGY UTILIZATION.. 5

This program transfers new knowledge and innovative technology resulting from NASA's R&D programs for application in industry, medicine, and other public and private sector areas. Civil service engineering and science personnel provide a source of technical skills necessary to accomplish technology transfer to the public sector.

Explanation of Fund Requirements

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
A. Compensation and Benefits	148,007	150,041	148,903	149,531
1. Compensation	131,686	133,174	132,484	132,710
a. Permanent positions	128,507	129,220	128,958	129,071

The decrease from the 1986 budget estimate to the 1986 current estimate is due primarily to a refinement of the estimates.

Basis of Cost for Permanent Positions

In 1987 the cost of permanent positions will be $129,071,000, an increase of $113,000 from 1986. This increase is calculated as follows:

Cost of permanent positions in 1986		128,958
Cost increases in 1987		2,651
Within grade advances and career development		
Full year effect of 1986 actions	1,174	
Partial year effect of 1987 actions	1,477	
Cost decreases in 1987		-2,538
Turnover savings and abolished positions:		
Full year effect of 1986 actions	-1,320	
Partial year effect of 1987 actions	-1,218	
Cost of permanent positions in 1987		129,071

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
b. Non-permanent				
(1) Cost	1,463	1,878	1,573	1,573
(2) Man-years	122	151	129	129

The decrease from the 1986 budget estimate to the 1986 current estimate reflects reduced requirements from previous estimates. The cost of non-permanent positions from 1986 to 1987 is the same.

Distribution of Other Than Full Time Permanent Workyears

Program	Workyears
Cooperative education programs	74
Other temporary programs	16
Youth opportunity programs	39
Total	129

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
c. Overtime and Other Compensation	1,716	2,006	1,953	2,066

The decrease reflected in 1986 current estimate is due to a refinement of the estimates. A small increase for 1987 is because of increased program requirements.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Benefits	16,321	16,867	16,419	16,821

The distribution of these costs by major categories is as follows:

Category of Cost	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Civil Service Retirement Fund	8,999	8,962	8,600	8,515
Employee life insurance	329	362	380	440
Employee health insurance	3,706	3,902	3,723	3,864
FICA	289	529	550	683
Unemployment Compensation	1	5	5	5
Workmen's Compensation	1,543	1,512	1,587	1,624
Medicare	1,454	1,595	1,574	1,690
Total	16,321	16,867	16,419	16,821

The 1986 current estimate is changed from the 1986 budget estimate due to decreases in Civil Service retirement costs partially offset by increased FICA costs for new Government employees. The 1987 increase reflects benefits costs commensurate with compensation estimates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
B. Supporting Costs	1,451	1,300	1,620	2,647
1. Transfer of personnel	710	448	736	1,405

This estimate provides for personnel relocation costs, such as the expenses of selling and buying a home and the movement of household goods. The currently estimated levels for 1986 and 1987 reflect the estimated cost of anticipated relocations.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Personnel training	741	852	884	1,242

The purpose of the MSFC training program is to continue the development of skills and knowledge of civil service employees in order to more efficiently support MSFC's roles and missions in the Space Program. The benefits to be derived by NASA from the training and educational programs conducted at MSFC include: enhancement of scientific and engineering leadership in the scientific community; maintenance of a high degree of professional competency with the administrative and clerical work force; development of needed skills and knowledge required in MSFC mission activities; and extending MSFC work force capability and increasing productivity. Increases in the 1987 requirements are primarily to support the Center's increasing computer capabilities, and scientific and engineering related requirements in areas such as robotics, optical systems, software engineering, and propulsion technology.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
II. TRAVEL	5,075	5,300	5,228	5,670

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	4,525	4,611	4,669	5,088
B. Scientific and Technical Development Travel	99	250	120	132
C. Management and Operations Travel	451	439	439	450
Total Travel	5,075	5,300	5,228	5,670

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	4,525	4,611	4,669	5,088

Program travel is directly related to the accomplishment of the Center's mission, and accounts for almost ninety percent of the total travel. Travel requirements include those for ongoing programs such as the STS Operations, Spacelab, Space Station, Upper Stages development and operations, Space Telescope, Spacelab Payloads, Space Science and Applications payloads and basic supporting research and technology, as well as support to the planning and definition of potential new programs. The increase in the 1986 current estimate is based on the current requirements and using 1985 actuals to project 1986 costs. The increase in 1987 is primarily due to increased cost of travel and holding the number of trips level.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
B. Scientific and Technical Development Travel	99	250	120	132

Scientific and technical related travel permits employees to participate in meetings and technical seminars with representatives of the aerospace community. This participation allows them to maintain and to grow in technical excellence, and benefit from exposure to technological advances outside MSFC, as well as to present both accomplishments and concerns to their associates. These meetings are principally working panels convened to solve problems for the benefit of the Government. The decrease in the 1986 current estimate is consistent with 1985 experience. The increase in 1987 will permit the same level of travel as in 1986.

C. Management and Operations Travel...........	451	439	439	450

Management and Operations travel is required for the direction and coordination of general management matters. It includes travel by managers in such areas as personnel, financial management, and procurement activities and travel of the Center's top management to NASA Headquarters and other NASA Centers. This category of travel includes local travel, passenger vehicle rental and non-NASA travel. Local travel includes personal travel in and around the official station of the employee and includes tolls, parking fees and taxis. Passenger vehicle rental includes lease of commerical passenger vehicles. The current "fixed price" four-year commerical vehicle rental contract that MSFC has signed with a contractor ends in July 1986 and must be renegotiated. Non-NASA travel includes transportation of persons, per diem, and other incidental expenses for all non-NASA employees, such as unpaid members of research advisory committees and pre-employment interviews for NASA SES positions. The 1987 budget estimate is due to anticipated increases in travel costs.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of	Dollars)	
III. OPERATION OF INSTALLATION......................	43,536	45,722	44,344	45,999

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Facilities Services..........................	20,362	22,480	21,080	22,159
B. Technical Services...........................	8,761	9,532	9,554	9,445
C. Management and Operations....................	14,413	13,710	13,710	14,395
Total, Operation of Installation.........	43,536	45,722	44,344	45,999

Explanation of Fund Requirements

Operation of Installation provides a broad range of services, supplies, and equipment in support of the Center's institutional activities. These are divided into three major functional areas: Facilities Services, the cost of maintaining and repairing institutional facilties and equipment, and the cost of custodial services and utilities; Technical Services, the cost of automatic data processing for management activities, and the cost of educational and informational programs and technical shops supporting institutional activities; and Management and Operations, the cost of administrative communications, printing, transportation, medical, supply, and related services.

The decrease reflected in the 1986 current estimate from the budget estimate is due primarily to the delay and deferral of activities, and a rephasing of support contractor funding plans. The increase in 1987 includes rate increases for energy, support contracts, and the full year funding of support contracts.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
A. FACILITIES SERVICES	20,362	22,480	21,080	22,159

The Marshall Space Flight Center (MSFC) occupies 1,841 acres under a Department of the Army non-revocable lease in a complex of science and engineering laboratories and special development and test facilities. The complex encompasses 3.8 million gross square feet of building space on Redstone Arsenal. This physical plant houses an average daily on-Center population of approximately 4,800 personnel.

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Maintenance and Related Services	6,486	6,988	6,219	6,815
a. Facilities	5,762	6,074	5,477	6,028
b. Equipment	724	914	742	787
2. Custodial Services	4,480	4,492	4,602	4,325
3. Utility Services	9,396	11,000	10,259	11,019
Total, Facilities Services	20,362	22,480	21,080	22,159

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Maintenance and Related Services	6,486	6,988	6,219	6,815

This activity involves maintenance and operation of a total of 202 facilities (building, structures, and trailers). The 1986 current estimate reflects a decrease due to the rephasing of support service contract obligation plans and the deferral and delay of repair and alteration projects and replacement equipment. The increase from 1986 to 1987 reflects the escalation of support service contractor wages, and the full year funding of such contracts.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Custodial Services	4,480	4,492	4,602	4,325

Custodial services include janitorial services, security services, fire protection, trash removal, sanitary landfill operations, and related supplies and materials. Janitorial service is provided to about 3 million square feet of facility space and trash removal for approximately 115 separate locations. Security and fire protection services include 24-hour coverage of MSFC property, law enforcement, and motor vehicle registration and control. The increase from the 1986 budget to the 1986 current estimate is due to a greater rise in price levels than anticipated. The decrease from the 1986 current estimate to the 1987 estimate is due to anticipated decreases in Redstone Arsenal Support Activity (RASA) rates for fire protection and sanitary landfill, partially offset by anticipated price increases.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
3. Utility Services..........................	9,396	11,000	10,259	11,019

This function provides for the cost of electricity, steam, natural gas, water, and sewage disposal service provided by Redstone Arsenal Support Activity on a reimbursable basis. It also provides for the propane and burner fuel to generate steam for heating and cooling. The decrease from the 1986 budget estimate to the 1986 current estimate reflects the 1985 rate experience. The increase in 1987 is primarily due to anticipated rate increases in RASA provided utilities.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
B. TECHNICAL SERVICES	8,761	9,532	9,554	9,445

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing	5,694	6,290	6,211	6,178
a. Equipment	1,220	1,601	1,085	1,025
b. Operations	4,474	4,689	5,126	5,153
2. Scientific and Technical Information	1,282	1,366	1,459	1,498
a. Library	1,097	1,168	1,356	1,396
b. Education and information	185	198	103	102
3. Shop Support Services	1,785	1,876	1,884	1,769
Total, Technical Services	8,761	9,532	9,554	9,445

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing	5,694	6,290	6,211	6,178

Funds provide for centralized systems analysis, programming, operations, and related computational services to meet the management and administrative computing requirements. This category also includes maintenance of ADP equipment such as central site computers and associated equipment. Equipment maintained includes IBM 4341, FR-80 microfiche system, systems software support, and a key-to-disc which collects, controls, organizes, and edits raw data for input into the IMB 4341.

This function also provides for the development and utilization of computer techniques and systems programming of all digital computers and associated equipment. Also included is associated auxilliary support equipment such as film processors, Xerox microfiche printers, Xerox forms copiers, punch card accounting machines, and Univac 4020 terminals. This activity includes the operations of two large magnetic tape libraries; receipt, control, and distribution of program and data processing products; and testing and cleaning of magnetic tapes.

The decrease from the 1986 budget estimate to the 1986 current estimate and to the 1987 budget estimate reflects FY 1985 experience in planned purchase of equipment.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Scientific and Technical Information........	1,282	1,366	1,459	1,498

This activity provides for the cost sharing operation of the Redstone Scientific Information Center (RSIC) library on Redstone Arsenal and other scientific and technical information services. Scientific information and library services are provided to MSFC employees and associated NASA contractor personnel through RSIC operations. The RSIC contains a central collection of books and journals, periodicals, documents on microfilm, and technical papers. Operation of the RSIC by the Army is under direction of a joint MSFC/Army Redstone scientific information board, with shared costs. These funds also provide for the preparation of reproducible pages for publication of NASA technical manuscripts and related documents and MSFC's share of the operation of the MSFC Visitor Information Center located at the Alabama Space and Rocket Center. The increase from the 1986 budget estimate to the 1986 current estimate is due to increased costs at the RSIC. The 1987 increase is the result of anticipated RSIC costs.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
3. Shop and Support Service	1,785	1,876	1,884	1,769

These funds provide the Center with support in the areas of graphics, photographic services, and related supplies, materials, and equipment. The 1987 decrease is the result of the completion of several activities in 1986.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
C. MANAGEMENT AND OPERATIONS......................	14,413	13,710	13,710	14,395
Summary of Fund Requirements				
1. Administrative Communications...............	4,051	4,030	3,867	3,534
2. Printing and Reproduction..................	866	500	757	802
3. Transportation.............................	3,340	3,585	3,332	3,772
4. Installation Common Services................	6,156	5,595	5,754	6,287
Total, Management and Operations..........	14,413	13,710	13,710	14,395

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of	Dollars)	

Explanation of Fund Requirements

1. Administrative Communications...............	4,051	4,030	3,867	3,534

Communications support for MSFC consists of local telephone service, long distance telephone service and various kinds of other non-telephone communications. The MSFC central exchange provides local telephone service. Long distance telephone service is provided by the GSA. Included are such items as long distance commercial tolls and the autodin network which is used for ordering supplies and materials. In addition, these funds provide for the use of Weeden Mountain radio transmission facilities, support of the emergency warning system, and operations of MSFC's fire surveillance system. The decrease in the 1986 current and the 1987 estimate reflects 1985 experience and continuation of efforts to economize in this area.

2. Printing and Reproduction..................	866	500	757	802

A portion of MSFC's printing and reproduction requirements are met by a contractor operated on-site reproduction plant. MSFC purchases reproduction services from the Government Pringing Office (GPO), the Army, and private firms. Off-site printing is an overflow requirement that cannot be handled within the on-site workload or capability. The increase from the 1986 budget to the 1986 current estimate reflects higher escalation then previously anticipated based on the 1985 actuals. The 1987 increase is escalation.

3. Transportation.............................	3,340	3,585	3,332	3,772

Transportation includes operation and maintenance of vehicles and aircraft, transportation of related supplies and materials, and purchases of transportation equipment. Included is the maintenance of general purpose vehicles, material handling equipment, special purpose trailers and vehicles, equipment such as cranes, tractors, generators and welders; and intermediate and major inspections. Freight charges for shipment of materials and equipment by both surface and air transportation are also included. The decrease from the 1986 budget estimate to the 1986 current estimate reflects less than anticipated increases in fuel rates. The increase in 1987 is due to anticipated support service contractor wage rate escalation.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
4. Installation Common Services................	6,156	5,595	5,754	6,287

This activity provides administrative support to Center management and staff activities, medical services, and various other installation support services.

Center management and staff functions include patent counsel services, tort claims, and equal opportunity activities. Medical services provide occupational medicine and environmental health services for the maintenance and improvement of employee health at MSFC, with emphasis on prevention, diagnosis, treatment, and care of illnesses and injuries.

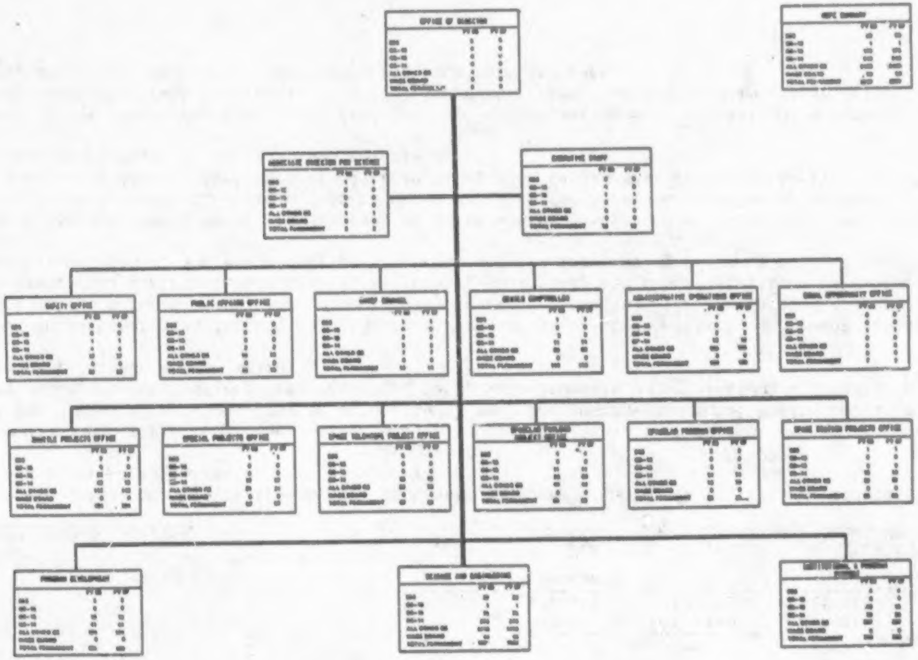
Installation support services include maintenance and repair of office equipment, equipment rental, acquisition of supplies and materials and other miscellaneous services such as: (1) receiving supplies, materials, and equipment; (2) distributing supplies, materials, equipment, and program-critical hardware; (3) preparing supplies, materials, and equipment for shipment, and (4) warehousing of raw materials.

Also provided are such services as the disposal of toxic waste, inspection of hazardous cargo prior to entry to Redstone Arsenal; receipt, storage, and issuance services for hazardous substances such as explosives, pyrotechnics and solid rocket motors; minor services such as laundry, furniture repair, toxic disposal, postage, and acquisition of supplies and materials.

The increase in the 1986 current estimate from the 1986 budget estimate is a result of expected support service contractor wage rate increases. The 1987 increase reflects anticipated increased price levels for supplies, materials, equipment, and contractor wage rate increases.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GEORGE C. MARSHALL SPACE FLIGHT CENTER



RPM 3-25

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987 ESTIMATES

NATIONAL SPACE TECHNOLOGY LABORATORIES

DESCRIPTION

The National Space Technology Laboratories is located in southwest Mississippi, approximately 50 miles northeast of New Orleans, Louisiana. Total land area is 138,807 acres of which 13,480 acres make up the actual installation owned by NASA. The remaining 125,327 acres are held as a buffer zone. In the buffer zone, 7,162 acres are owned by NASA and 118,165 acres are under restrictive easements. The installation has deep water access via the Pearl River and the Intercostal Waterway. Capital investment for the National Space Technology Laboratories, as of September 30, 1985, was $325,054,000.

CENTER ROLES AND MISSIONS

The National Space Technology Laboratories (NSTL), formerly the Mississippi Test Facility (MTF), is NASA's prime static test facility for large liquid propellant rocket engines and propulsion systems. The redesignation by NASA of MTF to the NSTL in June 1974 recognized the emerging role of the installation in space and environmental technology laboratories.

NSTL is presently engaged in development and acceptance testing of the Space Shuttle Main Engines and Main Propulsion System development testing. NSTL also conducts applied research and development in the fields of remote sensing, environmental sciences, and other selected applications programs. NSTL manages the installation and, through interagency agreements, provides support and maintains full utilization of all facilities by NASA and co-located elements of other executive agencies. These agencies are engaged in compatible research, development, and operational activities. They include the Department of Defense, the Department of Interior, the Department of Commerce, the Environmental Protection Agency, the Department of Transportation, the State of Mississippi, and the State of Louisiana. The principal roles are:

Space Shuttle: - NSTL provides, maintains and manages the facilities and the related capabilities required for the continued development and acceptance testing of the Space Shuttle Main Engines, and the development testing of the Shuttle's Main Propulsion Test Article which consists of a cluster of three main engines, an external tank and an orbiter aft-fuselage structure.

Space Applications: - Conducts fundamental and applied research, develops advanced airborne sensors and data/information systems, and conducts test and evaluation activities of remote sensing technology in the areas of renewable and non-renewable resources.

Support to Tenant Agencies: - Provides technical and institutional support to resident agencies.

SUMMARY OF RESOURCES REQUIREMENTS

Funding Plan by Function

(Thousands of Dollars)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
I. Personnel and Related Costs..................	5,013	5,104	5,142	5,193
II. Travel..	190	200	200	210
III. Operation of Installation.....................	5,466	6,052	5,565	6,050
A. Facilities Services.......................	(2,713)	(3,473)	(2,920)	(3,266)
B. Technical Services........................	(846)	(674)	(656)	(714)
C. Management and Operations.................	(1,907)	(1,905)	(1,989)	(2,070)
Total, fund requirements................	10,669	11,356	10,907	11,453

DISTRIBUTION OF PERMANENT CIVIL SERVICE WORKYEARS BY PROGRAM

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Space Transportation System	5	7	5	5
Space Transportation Capability Development	5	7	5	5
Space Science and Applications	41	34	44	44
Space Applicat[illegible]	41	34	44	44
Commercial Use o[illegible]	1	2	1	1
Subtotal, Direct Workyears	46	43	48	48
Center Management and Operations Support Positions	67	63	69	69
Total, Permanent Workyears	114	106	119	119
Other Than Full-Time	16	18	15	15
Total, Workyears	130	124	134	134

PROGRAM DESCRIPTION

Permanent Civil
Service Workyears

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT.................................. 5

In 1987, the National Space Technology Laboratories will continue to provide, maintain, and manage the facilities and the related capabilities required for development and acceptance testing of the Space Shuttle Main Engines.

SPACE APPLICATIONS.. 44

In 1987, the NSTL's Earth Resources Laboratory's program will continue to:

-- Conduct research investigations in the application of remotely sensed data using existing aircraft and satellite programs as a basic source of remotely sensed data in conjunction with surface data to develop techniques and procedures for practical applications.

-- Conduct applied research investigations for the application of new sensor data to priority information requirements of national concern in the areas of agricultural productivity, geological explorations, and land resources management including studies for aligning appropriate sensor technology with applicable disciplinary requirements.

-- Promote the effective transfer of applications technology as well as to reduce systems costs, and improve compatibility with other information sources and products.

-- Conduct research and development applications in non-remote sensing applications primarily in such areas as environmental system development and closed ecosystems development.

COMMERCIAL USE OF SPACE... 1

The objective of the Commercial Use of Space program is to increase private sector awareness of space opportunities and encourage increased investment and participation in high technology space-based research and development. This effort will establish an organizational focal point to initiate a program specifically intended to foster commercial use and access to space.

CENTER MANAGEMENT AND OPERATIONS SUPPORT.................................... 69

Center Management and Operations Support is defined as that support or services being provided to all NSTL organizations which cannot be identified exclusively to a single program or project. The civil service personnel involved are:

Director and Staff - The Installation Director, Deputy Director, and immediate staff, e.g., Legal, Equal Opportunity, and Public Affairs.

Management Support - Those who provide information and management services supporting all levels of Center management, both program and functional. Specific functions include resources and financial management, program control, contracting and procurement, property management, personnel management, and management systems and analysis.

Operations Support - Those who manage or provide for the operation and maintenance of institutional facilities, buildings, systems and equipment, including those who manage or provide technical services such as automatic data processing, reliability and quality assurance, medical care, and photographic support.

RESOURCE REQUIREMENTS BY FUNCTION

	1985 Actual	1986		1987 Budget Estimate
		Budget Estimate	Current Estimate	
	(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS	5,013	5,104	5,142	5,193
Summary of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Permanent positions	4,161	4,230	4,255	4,328
b. Other than full-time permanent positions	256	289	250	245
c. Overtime and other compensation	15	17	14	14
Subtotal, Compensation	4,432	4,536	4,519	4,587
2. Benefits	503	483	527	521
Subtotal, Compensation and Benefits	4,935	5,019	5,046	5,108
B. Supporting Costs				
1. Transfer of personnel	51	60	65	50
2. Personnel training	27	25	31	35
Subtotal, Supporting Costs	78	85	96	85
Total, Personnel and Related Costs	5,013	5,104	5,142	5,193

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
A. Compensation and Benefits	4,935	5,019	5,046	5,108
1. Compensation	4,432	4,536	4,519	4,587
a. Permanent positions	4,161	4,230	4,255	4,328

The increases in the 1986 current estimate and the 1987 budget estimate are due to normal career development.

Basis of Cost for Permanent Positions

In 1987, the cost of permanent positions will be $4,328,000, an increase of $73,000 over 1986. The increase results from the following:

Cost of permanent positions in 1986		4,255
Cost increase in 1987		91
Within grade and career advances:		
Full year effect of 1986 actions	69	
Partial year effect of 1987 actions	22	
Cost decreases in 1987		-18
Turnover savings and abolished positions:		
Partial year effect of 1987 actions	-18	
Cost of permanent positions in 1987		4,328

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
b. Other than full-time permanent positions				
1. Cost	256	289	250	245
2. Workyears	16	19	15	15

The distribution of 1987 workyears is as follows:

Distribution of Other than Full-Time Permanent Workyears

Program	Workyears
Developmental programs	4
Summer employment programs	---
Youth opportunity programs (Non-Ceiling)	---
Other temporary programs	11
Total	15

The decrease from the 1986 budget estimate to the 1986 current estimate is a decrease in the number of other than full time permanent employees. The 1987 decrease is the full year effect of the 1986 OTFTP personnel.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
c. Overtime and other compensation	15	17	14	14

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Benefits..................................	503	483	527	521

The following are the amounts of contribution by category:

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Civil Service Retirement Fund............	297	300	306	305
Employee Life Insurance..................	10	11	11	11
Employee Health Insurance................	119	114	121	116
FICA.....................................	22	9	38	39
Medicare.................................	48	49	49	50
Annuitant & Other Benefits...............	7	---	2	---
Total....................................	503	483	527	521

The increase from the 1986 budget estimate to the 1986 current estimate is the result of an increase in the number of permanent workyears. The 1987 estimate reflects the 1986 level of effort.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Supporting Costs	78	85	96	85
1. Transfer of personnel......................	51	60	65	50

The estimates for 1986 and 1987 are based on projected hiring plans.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Personnel training.........................	27	25	31	35

The personnel training program continues to develop the skills and knowledge of NSTL employees in order to more efficiently support NSTL roles and missions, primarily through "Upward Mobility" training for women and minorities and Equal Employment Opportunity Seminars. Increases in the 1986 current estimate and the 1987 budget estimate will be used to provide additional funding for NASA employee training to help maintain the current skill level.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
II. TRAVEL....................................	190	200	200	210

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel................................	92	105	97	108
B. Scientific and Technical Development Travel.....	4	5	4	4
C. Management and Operations Travel...............	94	90	99	98
Total, Travel................................	190	200	200	210

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel................................	92	105	97	108

Program travel requirements are directly related to the accomplishment of the Laboratories' mission, and will primarily be in support of Space Science and Applications Programs. Program travel accounted for about 45 percent of total travel in 1985. The decrease from the 1986 budget estimate to the 1986 current estimate reflects the 1985 experience. The increase from 1986 to 1987 includes expected increases in transportation costs.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Scientific and Technical Development Travel.....	4	5	4	4

Scientific and technical development travel will permit employees to participate in meetings and technical seminars with other representatives of the aerospace community. This participation allows personnel to retain technical competency and gain awareness of technological advances outside NSTL as well as to present both accomplishments and problems to associates. Many of the meetings are working panels convened to solve certain problems for the benefit of the Government.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
C. Management and Operations Travel................	94	90	99	98

Management and operations travel is used for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, and procurement activities as well as travel of the Laboratories' top management to NASA Headquarters and other NASA Centers. The increase from the 1986 budget estimate to the 1986 current estimate reflects expected transportation cost increases.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
III. OPERATION OF INSTALLATION.....................	5,466	6,052	5,565	6,050

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Facilities Services.........................	2,713	3,473	2,920	3,266
B. Technical Services..........................	846	674	656	714
C. Management and Operations..................	1,907	1,905	1,989	2,070
Total, Operation of Installation.......	5,466	6,052	5,565	6,050

Explanation of Fund Requirements

Operation of Installation provides a broad range of services, supplies, and equipment in support of the Center's institutional activities. These are divided into three major functional areas: Facilities Services, the cost of maintaining and repairing institutional facilities and equipment, and the cost of custodial services and utilities; Technical Services, the cost of automatic data processing for management activities, and the cost of educational and informational programs and technical shops supporting institutional activities; and Management and Operations, the cost of administrative communications, printing, transportation, and related services.

Funding deltas from the 1986 budget estimate to the 1986 current estimate are due to a reestimate of utility use requirements. The 1987 increase reflects the anticipated rate increases in support service contracts, utilities, and other goods and services required at NSTL.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
A. FACILITIES SERVICES	2,713	3,473	2,920	3,266

The NSTL covers 138,807 acres of grounds, and a complex of facilities which are comprised of laboratories, offices, and rocket engine test facilities. The complex encompasses some 1,172,098 gross square feet of building space. This physical plant supports an average daily on-site population of 3,023. Many of the test facilities are utilized on schedules involving more than one shift operation and operations during off-peak hours.

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Rental of Real Property	18	18	18	20
2. Maintenance and Related Services	582	480	569	584
a. Facility	574	440	529	554
b. Equipment	8	40	40	30
2. Custodial Services	325	344	330	343
3. Utility Services	1,788	2,631	2,003	2,319
Total, Facilities Services	2,713	3,473	2,920	3,266

1. Rental of Real Property	18	18	18	20

Provides for lease of hanger space for earth resources aircraft.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Maintenance and Related Services...........	582	480	569	584

This activity provides for the modifications and alterations of facilities and movements of personnel and equipment of the Earth Resources Laboratory (ERL) and equipment purchases for the ERL contracts. Also provided is the modification and alteration of facilities in support of B-1 test stand operations and maintenance. The 1986 current estimate is based on 1985 actuals and at current requirements. The 1987 increase reflects anticipated cost levels.

3. Custodial Services..........................	325	344	330	343

Provides for NASA's share of security guard services, janitorial services and fire protection services by the NSTL institutional support services contractor. The decrease in the 1986 budget estimate to the FY 1986 current estimate reflects lower support service contract wage rates than previously estimated.

4. Utility Services...........................	1,788	2,631	2,003	2,319

Provides for the purchase of the two utility commodities: electricity from the Mississippi Power Company and natural gas from the United Gas Pipe Line Company. Natural gas is the primary heating fuel used at NSTL. Also provided is NASA's share of the operation of the utility distribution and control systems, water wells, and sewage systems. The decrease from the 1986 budget estimate to the 1986 current estimate is the result of lower than anticipated utility rates. The increase in the 1987 budget estimate reflects expected rates for utilities, and anticipated support service contract wage rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
B. TECHNICAL SERVICES	846	674	656	714

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing	5	5	5	6
a. Engineering	-	-	-	-
b. Operation	5	5	5	6
2. Scientific and Technical Information	129	142	142	152
a. Library	4	4	4	4
b. Education and information	125	138	138	148
3. Shop and Support Services	712	527	509	556
Total, Technical Services	846	674	656	714

Explanation of Fund Requirements

1. Automatic Data Processing	5	5	5	6

Provides supplies and materials in support of the Center's ADP requirements.

2. Scientific and Technical Information	129	142	142	152

Provides books, periodicals, and other technical reports for the Center, and NASA's share of upgrading and operating the NSTL Visitor Information Center (VIC). The 1987 estimate includes current requirements at expected cost levels.

3. Shop and Support Services	712	527	509	556

Provides for NASA's share of such technical services as safety, photography and graphics. Provides for the purchase of O&M equipment and updated equipment to support the technical services at NSTL. The 1986 current estimate reflects support service contractor inflation rates lower than anticipated. The increase in the 1987 reflects expected cost escalation.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
C. MANAGEMENT AND OPERATIONS	1,907	1,905	1,989	2,070

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications	914	861	993	1,033
2. Printing and Reproduction	36	43	42	44
3. Transportation	843	881	839	873
4. Installation Common Services	114	120	115	120
Total, Management and Operations	1,907	1,905	1,989	2,070

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications	914	861	993	1,033

Provides for NASA's share of the local telephone service, Federal Telecommunications System (FTS), long distance and operation and maintenance of the on-site communications equipment and switchboard. The increase from the 1985 budget estimate to the current estimate reflects cost escalation. The increase from the 1986 current estimate to the 1987 budget estimate reflects expected cost escalation.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Printing and Reproduction	36	43	42	44

Provides for printing and reproduction services in support of the Earth Resources Laboratory and the local house organ. The increase from the 1986 current estimate to the 1987 budget estimate reflects expected cost escalation.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
3. Transportation..............................	843	881	839	873

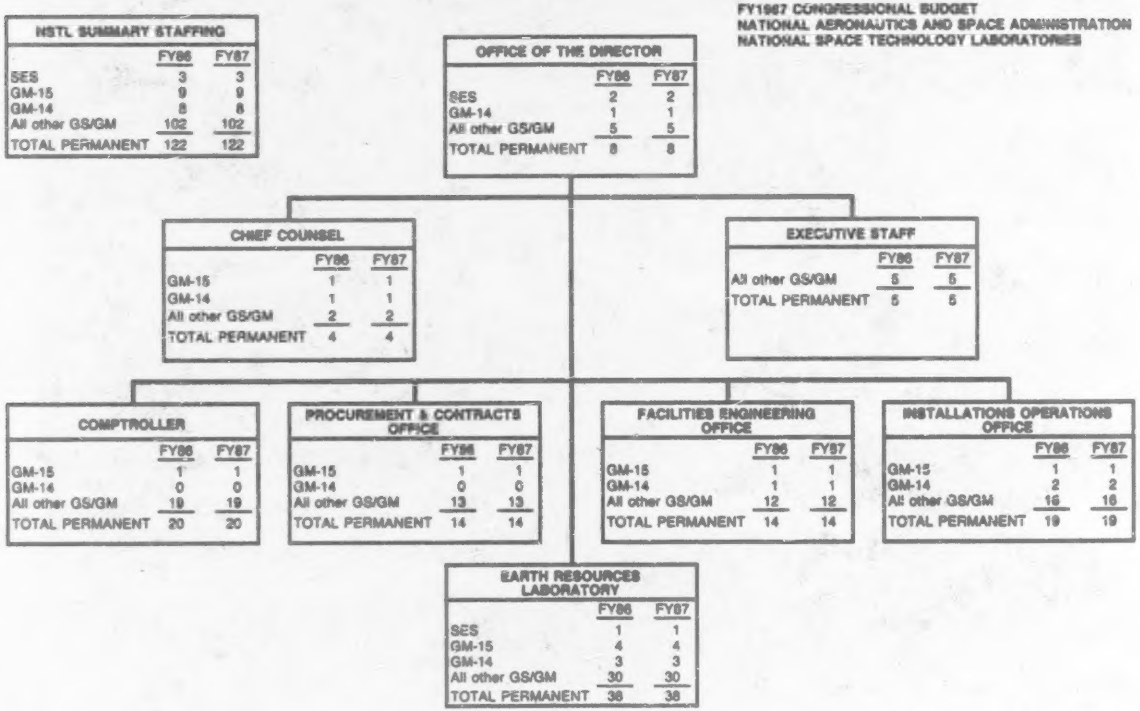
This estimate includes local transportation for the NSTL staff and the support contractors, as well as freight costs, government bills of landing, air freight, other general shipments and related transportation costs. The decrease in the 1986 budget estimate to the 1986 current estimate is due to rephasing of the support contract funding. The increase from the 1986 current estimate to the 1987 budget estimate reflects anticipated cost increases in vehicle rentals.

4. Installation Common Services................	114	120	115	120

Provides supplies, materials and equipment for the Center. The decrease from the 1986 budget estimate to the 1986 current estimate is due to rephasing of support service contractor obligation plans. The increase from the 1986 current estimate to the 1987 budget estimate reflects expected cost escalation for the same level of service.

ORGANIZATION CHART

FY1987 CONGRESSIONAL BUDGET
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NATIONAL SPACE TECHNOLOGY LABORATORIES



NSTL SUMMARY STAFFING

	FY86	FY87
SES	3	3
GM-15	9	9
GM-14	8	8
All other GS/GM	102	102
TOTAL PERMANENT	122	122

OFFICE OF THE DIRECTOR

	FY86	FY87
SES	2	2
GM-14	1	1
All other GS/GM	5	5
TOTAL PERMANENT	8	8

CHIEF COUNSEL

	FY86	FY87
GM-15	1	1
GM-14	1	1
All other GS/GM	2	2
TOTAL PERMANENT	4	4

EXECUTIVE STAFF

	FY86	FY87
All other GS/GM	5	5
TOTAL PERMANENT	5	5

COMPTROLLER

	FY86	FY87
GM-15	1	1
GM-14	0	0
All other GS/GM	19	19
TOTAL PERMANENT	20	20

PROCUREMENT & CONTRACTS OFFICE

	FY86	FY87
GM-15	1	1
GM-14	0	0
All other GS/GM	13	13
TOTAL PERMANENT	14	14

FACILITIES ENGINEERING OFFICE

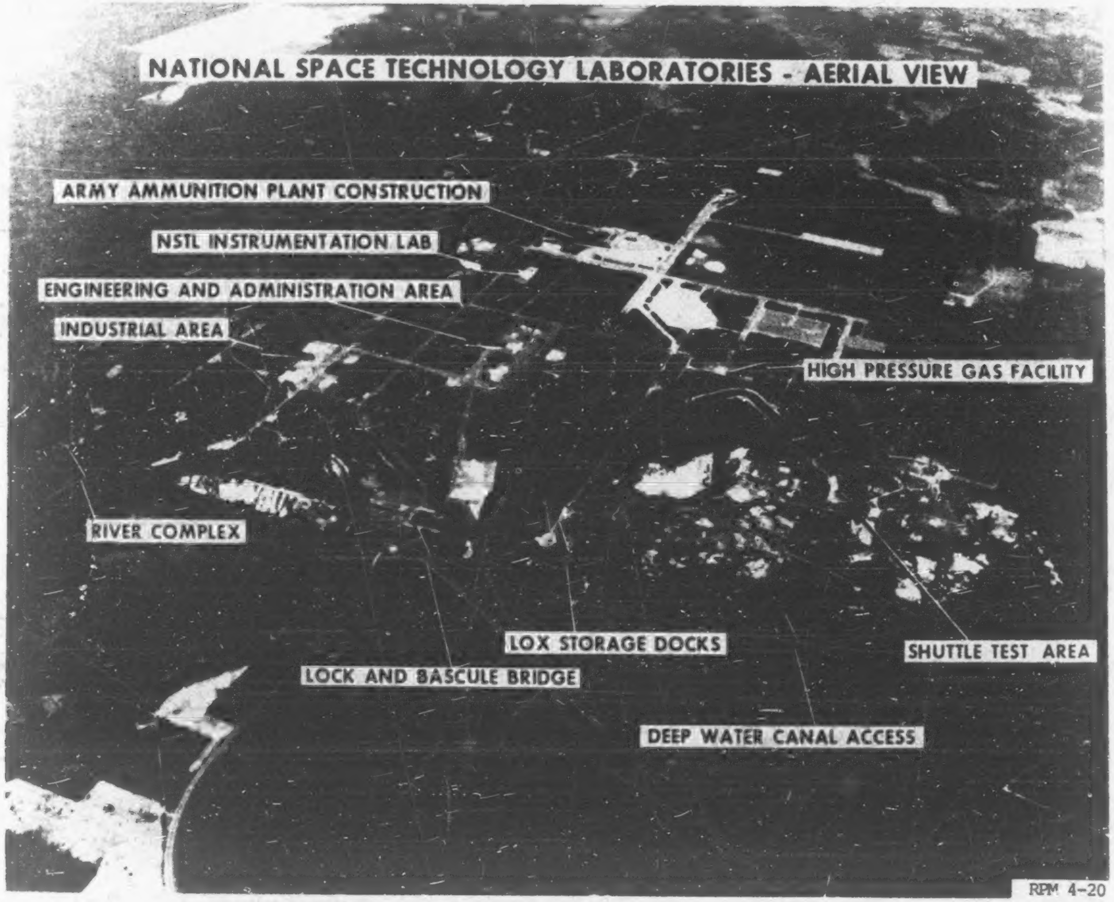
	FY86	FY87
GM-15	1	1
GM-14	1	1
All other GS/GM	12	12
TOTAL PERMANENT	14	14

INSTALLATIONS OPERATIONS OFFICE

	FY86	FY87
GM-15	1	1
GM-14	2	2
All other GS/GM	16	16
TOTAL PERMANENT	19	19

EARTH RESOURCES LABORATORY

	FY86	FY87
SES	1	1
GM-15	4	4
GM-14	3	3
All other GS/GM	30	30
TOTAL PERMANENT	38	38


NATIONAL SPACE TECHNOLOGY LABORATORIES - AERIAL VIEW
ARMY AMMUNITION PLANT CONSTRUCTION
NSTL INSTRUMENTATION LAB
ENGINEERING AND ADMINISTRATION AREA
INDUSTRIAL AREA
HIGH PRESSURE GAS FACILITY
RIVER COMPLEX
LOX STORAGE DOCKS
SHUTTLE TEST AREA
LOCK AND BASCULE BRIDGE
DEEP WATER CANAL ACCESS

RPM 4-20

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987 ESTIMATES

GODDARD SPACE FLIGHT CENTER

DESCRIPTION

The Goddard Space Flight Center (GSFC), located 15 miles northeast of Washington, D.C., at Greenbelt, Maryland, is situated on a 552-acre main site. Three additional nearby plots of 554 acres comprise the remote site area and contain the Goddard Antenna Test Range, the Goddard Optical Facility, the Propulsion Research Facility, the Laser Facility, the Magnetic Fields Component Test Facility, the Attitude Control Test Facility, and the Network Training and Test Facility. The Center also utilizes an additional 6,176 acres at the Wallops facility located on the Atlantic Coast of Virginia's eastern shore. The Wallops facility consists of 1,833 acres on the main base, 3,095 acres on Wallops Island launching site, 108 acres on the mainland tracking site, and 1,140 acres of marshland. The total capital investment for the Goddard Space Flight Center, including tracking stations, work in progress, contractor-held facilities at various locations, and the Wallops facility, as of September 30, 1985, was approximately $821,565,000.

The majority of the Goddard Center's personnel are located at Greenbelt, Maryland. Other personnel are located at the Wallops facility in Virginia, the Goddard Institute for Space Studies in New York City, and at various world-wide sites, managing the operation of satellite tracking and communications network stations.

CENTER ROLES AND MISSIONS

The GSFC, established in 1959 as the first major United States installation devoted to the investigation and exploration of space, conducts a wide-ranging program in earth and space sciences. The GSFC has developed many diverse capabilities: the management of complex projects; the development of wholly integrated spacecraft, ranging from systems engineering to development, integration, and testing; the development and operation of satellite tracking networks, and data acquisition and analysis; scientific research to include both theoretical studies and the development of many significant scientific experiments flown on satellites; and the operation of a research airport, located at Wallops, in support of NASA's aeronautics research programs. The principal and supporting roles are:

PRINCIPAL:

Earth Orbital Spacecraft Development, On-Orbit Servicing and Flight Operations - includes spacecraft propulsion and supporting technology such as low cost structural evaluation and reliability demonstration, advanced guidance systems and space power systems. Major emphasis is on automated, standard spacecraft systems, free-flyers, experiment development and integration, on-orbit free-flyer and payload servicing, Space Station Platforms, and the planning and conducting of associated flight operations.

Tracking and Data Acquisition Systems and Support Operations - plans, develops, implements and operates tracking facilities and provides for the related data processing, communications, and mission control; plans and conducts support of Earth orbital spacecraft, aeronautical research and sounding rockets; and network planning and implementation support for the Shuttle. This includes the implementation of the Tracking and Data Relay Satellite System (TDRSS).

Launch Range and Research Airport Management and Operations - plans and operates the Wallops launch range, associated aircraft, and a research airport in support of NASA aerospace programs as well as other Government agencies, such as the Department of Defense, and the academic and international community. Launch support and related services are provided for various sounding rockets and the expendable Scout launch vehicles launched at the Wallops facility.

Expendable Launch Vehicles - Goddard is the management center for the Delta launch vehicle.

Space Science and Applications - develops the bases for science and technology disciplines, develops and calibrates spaceborne sensors, and ground data processing and analysis systems, conducts scientific research and theoretical modeling studies, and implements science and applications experiments in astronomy, solar physics, high energy astrophysics, solar terrestrial studies, and atmospheric, oceanic and land processes.

Sounding Rocket Development, Procurement and Operations - develops and procures sounding rockets and carries out all phases of operations from mission/flight planning to landing and recovery, including supporting systems (i.e., guidance, telemetry and attitude control, power, payload housing, separation systems, and recovery).

Balloon Program - manages and provides technical oversight and direction to the balloon activities conducted for NASA and other agencies.

Spacelab Payload Development - develops, analytically integrates and processes data for Spacelab payloads in astrophysics, solar terrestrial physics, astronomy, and applications.

Special Payloads - manages and develops low cost reusable carrier systems which accommodate a variety of payloads to be flown on Shuttle missions. Three basic carrier systems are currently on-line to support Spartan, Get-Away Specials (GAS), and Hitchhiker payloads. These payloads, when ready, will be integrated and tested with the carrier and then flown with compatible Shuttle missions. These activities involve development and operation of diverse mechanical, power, electrical, aerodynamic, propulsion, control, thermal and combined systems. In addition, center personnel coordinate with an international array of experimenters (including private citizens, and representatives from high schools, universities, industry and other Government agencies) to accommodate their investigations with the carrier and Shuttle systems.

SUPPORTING:

Planetary Science - develops and applies techniques for the investigation and analysis of planetary atmospheres.

Aerospace Flight Test Support - plans and conducts launches of scientific payloads and aeronautical tests and other research, development and related activities as requested by elements of NASA, the Department of Defense, other Government agencies, and the worldwide scientific community.

SUMMARY OF RESOURCES REQUIREMENTS

FUNDING PLAN BY FUNCTION

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs......................	154,834	160,724	160,859	162,915
II. Travel..	4,458	4,314	4,600	4,900
III. Operation of Installation......................	37,565	41,590	38,471	46,523
A. Facilities Services..........................	(19,850)	(24,192)	(21,368)	(24,760)
B. Technical Services...........................	(5,058)	(5,999)	(6,009)	(9,694)
C. Management Operations........................	(12,657)	(11,399)	(11,094)	(12,069)
Total, fund requirements..................	196,857	206,628	203,930	214,338

DISTRIBUTION OF CIVIL SERVICE WORKYEARS BY PROGRAM

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
RESEARCH AND DEVELOPMENT	2,230	2,223	2,307	2,328
Space Station	122	113	175	200
Space Transportation Capability Development	26	13	14	14
Space Science and Applications	1,957	1,949	2,006	2,000
Physics and Astronomy	1,134	1,150	1,160	1,105
Life Sciences	1	1	1	1
Planetary Exploration	80	77	76	75
Space Applications	742	722	768	819
Commercial Programs	11	14	9	9
Technology Utilization	10	10	8	8
Commercial Use of Space	1	4	1	1
Aeronautics and Space Technology	88	105	77	78
Aeronautical Research and Technology	10	13	9	9
Space Research and Technology	78	92	68	69
Space Tracking and Data Advanced Systems	26	28	27	27
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	656	687	633	613
Space Transportation Operations	69	85	71	61
Space and Ground Networks, Communication and Data Systems	587	602	562	552
Subtotal, Direct Workyears	2,886	2,910	2,940	2,941
CENTER MANAGEMENT AND OPERATIONS SUPPORT	673	659	636	635
Subtotal Permanent Workyears	3,559	3,569	3,576	3,576
Other than full-time permanent	108	100	99	99
Total, permanent workyears	3,667	3,669	3,675	3,675

Permanent Civil
Service Workyears

SPACE STATION.. 200

Space Station activities involve the evaluation of proposals and initial studies for definition of user science requirements, automated free-flying platforms, laboratory module outfitting and provisions to service, maintain and repair space platforms and free-flying spacecraft. In addition, systems engineering and integration efforts will be performed in direct support of the Johnson Space Center. Discipline studies in thermal and data systems requirements will be conducted. Working groups of scientists will be activated to involve potential users in Space Station requirements definition.

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT.................................... 14

GSFC is developing the Hitchhiker, a reusable carrier system which will provide increased flight opportunities with reduced leadtime, maximizing Shuttle load factors and minimizing spaceflight costs.

PHYSICS AND ASTRONOMY.. 1,105

Astrophysics activities at GSFC are pursued to accomplish laboratory and flight scientific research to increase human knowledge of the Earth's space environment, the stars, the Sun, and other objects in space; and provide advanced technical development of experiments and spacecraft components for future astrophysics missions. GSFC manages activities in the pursuit of scientific progress in all of the following areas of astrophysics: gamma ray astronomy, X-ray astronomy, ultraviolet and optical astronomy, infrared and radio astronomy, particle astrophysics, solar physics, interplanetary physics, planetary magnetospheres, and astrochemistry.

During 1986, the Hubble Space Telescope will be launched. HST will provide a space observatory and dedicated ground system to extend the sensitivity, resolving power, and spectral range of astronomical observatories significantly beyond those achievable from ground-based observations. Development activities will continue on the Gamma Ray Observatory mission, the Cosmic Background Explorer, various Shuttle/Spacelab Payloads and integrated rocket experiments; and the analysis of data from several major Physics and Astronomy missions including the High Energy Astronomy Observatories, the Dynamics Explorer, the repaired Solar Maximum Mission and the Active Magnetospheric Particle Tracer Explorer.

The International Ultraviolet Explorer spacecraft, with its unique satellite control and data management systems, will continue to afford guest observers the opportunity to point the satellite in real-time from the ground, make quick observations, and receive data in visual formats.

During 1986 and 1987, GSFC will be responsible for the continued development of a U.S. supplied focal plane, high resolution imaging instrument to be flown on the German Roentgen Satellite which is scheduled for launch in 1987 on the Space Shuttle. The Roentgen Satellite, another NASA international cooperative project with the Federal Republic of Germany, will perform the first all sky survey of X-ray sources and will point to and study specific X-ray sources for extended periods of time.

Goddard will provide the management and support of the NASA domestic and international sounding rocket programs. The project extends from conception through launch and analysis of the data obtained in the following areas: galactic astronomy, high energy astrophysics, solar physics, plasma physics, upper atmospheric and interdisciplinary research, and the space applications of materials processing science. During 1986 and 1987, Goddard will continue development of sounding rocket class payloads for flight on the Space Shuttle. This is a cost-effective approach which allows instruments to be flown for much longer periods of time than available with sounding rockets.

Goddard will continue to manage the scientific balloon program providing for launch and tracking support, flight hardware, and technical support including new systems development. Goddard has responsibility for operation of the National Scientific Balloon Facility at Palestine, Texas, and provides management and technical oversight.

Permanent Civil
Service Workyears

LIFE SCIENCES.. 1

The Goddard Life Sciences activities involve the utilization of remote sensing satellites to increase our understanding of global biological characteristics and processes.

PLANETARY EXPLORATION.. 75

The GSFC activity within Planetary Exploration emphasizes the physics of interplanetary space environments. To this end, GSFC will maintain a strong and viable research group, with participation in instrument development and mission generations and data analysis activity.

SPACE APPLICATIONS... 819

The 1986 and 1987 program activities will span GSFC's broad roles and missions mandate, including activities in the discipline areas of land, oceans, and atmospheric sciences. GSFC is engaged in three major types of activities in these areas: research and technology, flight projects, and data analysis.

The research and technology effort is directed toward solving major problems in the disciplines mentioned and involves conceptual instrument design and testing, mission payload studies, and conceptual flight missions. This is accomplished through the design and construction of mathematical models to study:

1. The global circulation of the Earth's atmosphere for better weather and climate predictions;

2. The geopotential fields (gravity and magnetic) of the Earth to provide a better understanding of the structure and evolution of the Earth;

3. The processes of the oceans such as surface winds, waves, temperature, currents, and circulation to support the ongoing weather and climate studies and the ocean research program;

4. The physical characteristics of the Earth's vegetation cover, water resources, and land use which can be remotely sensed; and

5. The interaction between the Earth's atmosphere, hydrosphere, and cryosphere.

Some examples of instrumentation activities which GSFC is supporting include instrumentation for measuring temperature and pressure profiles in the atmosphere which are essential parameters for weather and climate models; user active and passive microwave systems for measuring sea surface temperatures and winds, and measurement of soil moisture essential for water resources modeling and agricultural yield predictions; new instruments for ocean color measurements; and high precision laser electronic ranging systems in support of the Earth and ocean dynamics activities.

At GSFC flight project responsibilities in 1986 and 1987 include:

1. Operational weather satellite missions for the National Oceanic and Atmospheric Administration (NOAA), including launch of NOAA-G, GOES-G, and GOES-H in 1986;
2. Continued operations of the Nimbus satellites to provide remotely sensed resources data and environmental observations to a worldwide applications research community;
3. The data from the Landsat-4 and 5 will continue to be analyzed to evaluate the benefits of a new generation of land observation instruments;
4. Earth Radiation Budget Experiment data will be collected for the study of geographical and seasonal variations of the Earth's radiation budget;

5. Conducting correlation measurements from balloons, sounding rockets, aircraft, and ground installations; and

6. Development activities will be continued on the Upper Atmospheric Research Satellite instrument and the spacecraft, leading to a launch in the fall of 1989.

Earth Science activities involve the formulation, analysis, and distribution of data received from satellites for which GSFC has management responsibility. Such demonstrations involve the use of data from the Nimbus-7 spacecraft for the solution of problems concerning pollution, ocean resources and dynamics, and weather and climate. Similar activities will be conducted by using the data from Landsat-4; this information will be of use to investigators in the disciplines of agriculture, forestry, geology, land use, cartography, hydrology, ecology, and oceanography. Solar Terrestrial research efforts will include analysis of data collected from operating satellites such as the Dynamics Explorer, the Interplanetary Monitoring Platform and the International Sun-Earth Explorers, which are providing opportunities to study the dynamic interactions of the solar wind and the Earth's magnetosphere from various points in space. On September 11, 1985, ICE accomplished a successful rendezvous with Comet Giacobini-Zinner. ICE is the first spacecraft in history to fly through the tail of a Comet.

Permanent Civil
Service Workyears

TECHNOLOGY UTILIZATION.. 8

Technology Utilization activities are directed toward the application of space technology to public and private sector needs. Foremost among the technology applications projects in 1986 and 1987 are the cerebrospinal fluid control system, the closed loop system for hypertension, and applications of the programmable implantable medication system. Other activities include: (1) new technology identification, evaluation, and publication; (2) dissemination methods and techniques; and (3) public sector technology applications projects.

COMMERCIAL USE OF SPACE.. 1

The objective of the Commercial Use of Space program is to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology space-based research and development. This effort will establish an organizational focal point to initiate a program specifically intended to foster commercial use and access to space.

AERONAUTICAL RESEARCH AND TECHNOLOGY.. 9

In 1986 and 1987, the Wallops airport will be used to conduct research tests of various aircraft in their terminal area operating environment. Flight studies will be made of new approach and landing procedures utilizing the latest in guidance equipment and techniques, pilot information displays, terminal area navigation, and tests of other systems leading to all weather automatic landing of aircraft.

One runway is being used to study aircraft hydroplaning, water ingestion and tire design on wet or slush-covered surfaces. The data acquired from this research testing will ultimately assist in the development of safer, more flexible transportation systems. Wallops will continue to support aircraft noise and safety research for general aviation.

Permanent Civil
Service Workyears

SPACE RESEARCH AND TECHNOLOGY.. 69

The Space Research and Technology Program activities provide results appropriate to space missions. Past efforts have produced many worthwhile advances in space system capability, reliability, and effectiveness. During 1986 and 1987, program areas of continuing emphasis will include sensor technology, data base systems computer system science, power and thermal systems, and spacecraft systems. New initiatives are planned in automation and robotics, laser communications, and space flight experiments.

TRACKING AND DATA ADVANCED SYSTEMS... 27

Goddard's activity in this area involves the investigation and development of advanced tracking and data acquisition systems techniques. The primary objectives are to: (1) obtain new and improved tracking and data capabilities that will meet the needs of approved new missions; and (2) improve the cost effectiveness and reliability needed for overall support of space flight missions.

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

SPACE TRANSPORTATION OPERATIONS... 61

Space Shuttle activities at GSFC include planning and implementing the equipment systems, communications data, voice circuits, and operational procedures required for support of the Shuttle program.

Goddard manages and coordinates the Agency's Get-Away-Special Program. Center personnel coordinate with an international array of experimenters (including private citizens, high school and university students, and industry) who have procured, through Agency established procedures, payload space on the Shuttle. Tasks include ensuring that experiments meet flight and safety specifications and securing the experiments into containers for Space Shuttle flight. Individual experimenters are responsible for the performance of their instruments/experiments.

Activities also include the management of a flight support system which is the electromechanical interface between the orbiter and Multimission Modular Spacecraft and other spacecraft with compatible interface parameters. It will be used for ascent, retrieval, repair, and descent phases of Space Shuttle flights carrying Multimission Modular Spacecraft and other compatible spacecraft.

Goddard is the management center for the Delta expendable launch vehicle which is capable of accurately putting a wide variety of spacecraft into a broad spectrum of orbits, ranging from equatorial to polar inclinations. The Delta has been used for a wide range of reimbursable missions for other Government agencies, domestic commercial users, and international users, currently with 44 consecutive successful launches. The Delta vehicle has served the Agency for nearly three decades and will be phased out in 1987 as a Government-managed expendable vehicle program. A Scout launch capability is maintained by the Wallops facility.

	Permanent Civil Service Workyears
SPACE AND GROUND NETWORKS, COMMUNICATION AND DATA SYSTEMS......................	552

The Space Tracking and Data Systems program at GSFC involves five main areas: operation of the Space Tracking and Data Network; mission control, data processing, and orbit/attitude computation support for flight projects; the TDRSS; the NASA Communications (NASCOM) Network; and aeronautics and sounding rocket support.

The Space Tracking and Data Network is operated in direct support of NASA's Earth orbiting scientific and applications satellites and Shuttle/Spacelab programs. In addition, the Network provides on a reimbursable basis services to satellites that are operated by other United States Government Agencies, such as the Department of Defense and the National Oceanic and Atmospheric Administration, by foreign Governments, and by commercial companies. Appropriate segments of the Network deliver critical coverage for the launch of spacecraft that are on deep space missions by providing support during portions of the early flight path not visible to NASA'S Network (DSN).

The NASA Communications Network (NASCOM) provides all operational communications required by NASA. Facilities of this network link the stations of the Space Tracking and Data Network, the TDRSS, the DSN, and other tracking and data acquisition support elements with control centers, and the data processing and computation center, thereby making it possible for all participants to operate as a network.

GSFC provides tracking, data acquisition, communication, and control in support of the aeronautics and sounding rockets program. This includes support of balloons, sounding rockets, reentry vehicles and satellites launched from Wallops Island and other offsite range locations.

The Tracking and Data Relay Satellite System will become operational during 1986 with three operational satellites in geosynchronous orbit and the White Sands Ground Terminal providing telemetry, tracking, and command support. The system employs both S- and Ku-band frequencies and will greatly increase coverage capabilities available to Earth orbiting spacecraft. The network will provide the operational interface between the project users and the TDRSS. With the demonstration of a successful TDRSS, a number of Spaceflight Tracking and Data Network ground stations will be closed. Two of the current stations will be maintained to provide for Shuttle launch and planetary support.

During 1986 and 1987, the GSFC Tracking Network will provide tracking for the Space Transportation System launched payloads.

Ground station support will also be continued for a number of operating satellites such as the International Sun Earth Explorers, International Ultraviolet Explorer, Solar Maximum Mission, and Nimbus. Some examples of this support include: mission control, orbit/attitude computing, and sensor data processing.

During 1986 and 1987, emphasis will continue to be placed on the operation of the Spacelab, Image, and Telemetry Data Processing Facilitise. In 1986, software development activities relative to the Hubble Space Telescope Data Capture Facility will be completed.

Design and development of a generic data capture facility began in 1985. This system, when implemented, will minimize the repetitive development costs currently encountered in the support of different scientific missions. These activities will be continued in 1986 and conclude in 1987.

The first release of consolidated orbit computation software was completed in 1985 with subsequent releases scheduled for completion in 1986 and 1987. This software will provide the capability to perform realtime and non-realtime orbit determination as well as orbit computation product generation and tracking data evaluation with a single software system on a single processor.

In the area of mission control, work will continue in 1986 on the Multisatellite Operations Control Center to allow for the automation of systems in order to minimize manpower requirements for mission support. Likewise, work will proceed in the Hubble Space Telescope Operations Control Center to ready that facility for observer activities beginning in 1986.

In order to support the appropriate use of the most advanced technologies in these data systems, prototypes will be developed to provide lower cost and higher performance data handling components; to incorporate routine operations decisions in expert systems to reduce manpower costs; and to provide automated tools for software engineering and systems development management. An interactive systems prototyping environment will be assembled to allow simulation of critical man-machine operations interfaces early in the development cycle to reduce the need for expensive design changes later in the cycle. An integrated, distributed data base system will be implemented to improve the flow of management and technical information.

	Permanent Civil Service Workyears
CENTER MANAGEMENT AND OPERATIONS SUPPORT....................................	635

Center Management and Operations Support is defined as support or services being provided to all GFSC organizations which cannot be identified exclusively to a single program or project. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director and the immediate staff, staff organizations, e.g., Comptroller, Chief Counsel, Equal Opportunity, and Public Affairs.

Management Support - Those who provide information and control services supporting all levels of Center management, both program and functional. Specific functions include resources and financial management, contracting and procurement, property management, personnel management, and management systems and analysis.

Operations Support - Those who provide for the operation and maintenance of institutional facilities, buildings, systems and equipment, including those who manage or provide technical services such as automated data processing, health and safety, and medical care.

RESOURCES REQUIREMENTS BY FUNCTION

(Thousands of Dollars)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
I. PERSONNEL AND RELATED COSTS	154,834	160,724	160,859	162,915

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Compensation and Benefits				
1. Compensation				
a. Full-time permanent	134,201	139,364	139,279	140,552
b. Other than full-time permanent	1,925	1,866	2,000	2,000
c. Overtime and other compensation	2,078	2,254	2,302	2,332
Subtotal, Compensation	138,204	143,484	143,581	144,884
2. Benefits	14,623	15,224	15,083	15,552
Subtotal, Compensation and Benefits	152,827	158,708	158,664	160,436
B. Supporting Costs				
1. Transfer of personnel	443	378	570	694
2. Personnel training	1,564	1,638	1,625	1,785
Subtotal, Supporting Costs	2,007	2,016	2,195	2,479
Total, Personnel and Related Costs	154,834	160,724	160,859	162,915

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
A. Compensation and Benefits........................	152,827	158,708	158,664	160,436
1. Compensation..................................	138,204	143,484	143,581	144,884
a. Permanent workyears......................	134,201	139,364	139,279	140,552

The increase in compensation from the 1986 budget estimate to the 1986 current estimate is due to an increase in FTE allocation. The increases in Compensation and Benefits from the 1986 current estimate to the 1987 budget estimate are due to the adjustments described below.

Basis of Cost for Permanent Workyears

In 1987, the cost of permanent workyears will be $140,552. The increase from 1986 is calculated as follows:

Cost of full-time permanent workyears in 1986..		139,279
Cost increases in 1987..		4,161
Within-grade and career advances:		
Full year cost of 1986 actions..	1,610	
Part year cost of 1987 actions..	1,785	
Decrease in reimbursements received..	766	
Cost Decreases in 1987..		-2,888
Turnover savings and abolished positions:		
Full year effect of 1986 actions..	-1,462	
Partial year effect of 1987 actions..	-1,426	
Cost of full-time permanent workyears in 1987..		140,552

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
b. Other than full-time permanent workyears				
1. Cost	1,925	1,866	2,000	2,000
2. Workyears	129	136	130	130

The distribution of 1987 workyears is as follows:

Distribution of Other than Full-Time Permanent Workyears

Program	Workyears
Developmental programs	58
Other temporary	41
Youth opportunity programs	31
Total	130

The level of support remains constant for these programs.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
c. Overtime and other compensation	2,078	2,254	2,302	2,332

The increases from the 1986 budget estimate to the 1986 current estimate and from the current estimate to the 1987 budget estimate reflect a centerwide emphasis on awards for performance and productivity accomplishments.

The following are the amounts of contribution by category:

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Civil Service Retirement Fund	8,678	9,302	8,942	9,225
Employee Life Insurance	285	384	304	314
Employee Health Insurance	3,450	3,484	3,566	3,679
Workmen's Compensation	276	300	300	325
FICA	383	70	396	409
Medicare	1,542	1,664	1,575	1,600
Other	9	20	---	---
Total	14,623	15,224	15,083	15,552

Adjustments to Civil Service Retirement and FICA from the 1986 budget estimate to the 1986 current estimate are due to changes in Civil Service retirement law as applied to newly hired employees. The increase in benefits from the 1986 current estimate to the 1987 budget estimate is concomitant with salary adjustments for permanent workyears.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Support Costs	2,007	2,016	2,195	2,479
1. Transfer of personnel	443	378	570	694

The category includes the reimbursement of employees for movement of household goods to the employee's new duty station, transfer between tracking stations, and other relocation expenses. The increase from the 1986 budget estimate to the 1986 current estimate reflects the costs associated with a new contract for services to assist employees in permanent change of station moves. The 1987 estimate reflects the planned level of transfers at the anticipated cost levels.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Personnel Training	1,564	1,638	1,625	1,785

The personnel training costs are based on current training programs and the need to reorient employees' skills into areas compatible with the needs of the current space program and GSFC's role in the program. The 1987 estimate is based on the projected cost for the current level of requirements.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
II. TRAVEL	4,458	4,314	4,600	4,900

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	3,793	3,830	3,914	4,184
B. Scientific and Technical Development Travel	302	262	320	346
C. Management and Operations Travel	363	222	366	370
Total, Travel	4,458	4,314	4,600	4,900

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	3,793	3,830	3,914	4,184

Program travel is essential to the accomplishment of the Center's mission, particularly with regard to the Space Science and Applications, Aeronautics and Space Technology, Tracking and Data Acquisition, Space Transportation System and Space Station programs. In these areas, efforts will be devoted to performing applications research, developing complex satellites and launch systems, managing data processing systems, and creating scientific instruments for further research. The increase from the 1986 budget estimate to the 1986 current estimate reflects an increase for Space Station expenditures. The increase in the 1987 estimate reflects approximately the same level of travel at higher anticipated travel costs and an increase for Space Station expenditures.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Scientific and Technical Development Travel	302	262	320	346

Scientific and technical development travel permits employees to participate in meetings and technical seminars with other representatives of the aerospace community. This participation allows personnel to benefit from exposure to technological advances outside GSFC, as well as to present both accomplishments and problems to associates. Many of the meetings are working panels convened to solve certain problems for the benefit of the government. The increase from the 1986 budget estimate to the 1986 current estimate is based on the same level of requirements as 1985 actuals at 1986 rates. The increase in the 1987 budget estimate from the 1986 current estimate reflects rate increases for the current level of requirements.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
C. Management and Operations Travel.................	363	222	366	370

Management and operations travel is used for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, and procurement activities, travel of the Center top management to other NASA Centers and local travel in and around the Washington metropolitan area and to and from Wallops. The increase from the 1986 budget estimate to the 1986 current estimate reflects a revised number of trips for facilities engineering support at remote GSFC facilities, development of productivity initiatives, and recruiting. The 1987 budget estimate reflects rate increases for the current level of effort.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
III. OPERATION OF INSTALLATION	37,565	41,590	38,471	46,523

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Facilities Services	19,850	24,192	21,368	24,760
B. Technical Services	5,058	5,999	6,009	9,694
C. Management and Operations	12,657	11,399	11,094	12,069
Total, Operation of Installation	37,565	41,590	38,471	46,523

Explanation of Fund Requirements

Operation of installation provides a broad range of services, supplies, and equipment in support of the center's institutional activities. These are divided into three major functional areas: (1) Facilities Services, the cost of renting real property, maintaining and repairing institutional facilities and equipment, the cost of custodial services and utilities; (2) Technical Services, the cost of automatic data processing for management activities, and the cost of educational and informational programs; and (3) Management and Operations, the cost of administrative communications, transportation, medical, supply, and related services.

The decrease from the 1986 budget estimate to the 1986 current estimate is primarily due to lower than anticipated utility rates, support service contractor wage rates, a rephasing of support contractor obligation rates, and the delay and deferral of other activities. The 1987 budget estimate provides for projected increases in support contractor rates, supplies, materials, equipment and utility rates, the replacement of a critically needed administrative computer, and full year funding for support service contracts.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Facilities Services	19,850	24,192	21,368	24,760

The Greenbelt facility is located on a 552-acre main site, and on a 554-acre remote site area with a complex of laboratory and office-type buildings as well as test facilities. This complex encompasses 2.5

million gross square feet of building space including 34 buildings. This physical plant supports an average daily on-center population of about 6,000. Many of the test facilities are used on schedules involving more than one shift, often during off-peak hours.

The Wallops facility includes 6,175 acres and a complex of facilities which mainly consists of a research airport and launch operations facilities. This complex encompasses 1.1 million gross square feet of building space including three major buildings. Also included are three major technical facilities. This physical plant supports an average daily on-site population of approximately 1,000.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Summary of Fund Requirements				
1. Rental of Real Property	680	695	615	694
2. Maintenance and Related Services	4,835	6,780	5,403	6,541
3. Custodial Services	4,343	4,773	4,348	4,763
4. Utility Services	9,992	11,944	11,002	12,762
Total, Facilities Services	19,850	24,192	21,368	24,760

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Rental of Real Property	680	695	615	694

Provides space for personnel at tracking stations and the Goddard Institute for Space Studies in New York. The decrease from the 1986 budget estimate to the 1986 current estimate reflects 1985 experience in rental payments to the General Services Administration, as well as closing the Chile tracking station. The increase in the 1987 budget estimate reflects GSA rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Maintenance and Related Services	4,835	6,780	5,403	6,541

This activity includes general building maintenance such as painting, inspection and mechanical and electrical maintenance. It provides for ground maintenance and also includes supplies and facilities equipment such as building materials, electrical and electronics materials, general maintenance and operating materials.

The decrease from the 1986 budget estimate to the 1986 current estimate reflects 1985 experience. The increase from 1986 to 1987 reflects anticipated support service contractor wage rate growth and expected increases in 1987 price levels for supplies, materials, equipment and other contractual effort.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
3. Custodial Services............................	4,343	4,773	4,348	4,763

The estimate provides for janitorial, plant security, fire fighting and ambulance services. These services include washing and relamping of light fixtures, office cleaning, minor laundry services, trash removal, badging of all on-site personnel and visitors, vehicle identification, and fire fighting. The decrease from the 1986 budget estimate to the 1986 current estimate reflects 1985 experience and the rephasing of support service contract funding. The increase in the 1987 budget estimate is due to anticipated rate changes in support service contracts, the provision of adequate security and fire protection, and the full year funding of support service contracts.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
4. Utility Services..............................	9,992	11,944	11,002	12,762

The estimate provides for maintenance of the utility plant and distribution systems as well as the purchase of utility services, and supplies, materials and equipment required for the maintenance of these systems. At the Greenbelt facility, electricity is purchased from the Potomac Electric and Power Company, natural gas from the Washington Gas Light Company, and fuel oil from a local supplier. Water and sewage service is provided by the Washington Suburban Sanitary Commission. The purchased utilities at Wallops are electricity and fuel oil. The decrease from the 1986 budget estimate to the 1986 current estimate and the increase from the 1986 current estimate to the 1987 budget estimate reflects the anticipated utility rate increases and the consumption projections from 1985 experience.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
B. Technical Services	5,058	5,999	6,009	9,694
Summary of Fund Requirements				
1. Automatic Data Processing	4,228	5,065	5,138	8,788
a. Equipment	800	1,306	1,115	4,373
b. Operations	3,428	3,759	4,023	4,415
2. Scientific and Technical Information	595	676	676	646
a. Library	31	44	45	47
b. Education and Information	564	632	631	599
3. Shop Support Services	235	258	195	260
Total, Technical Services	5,058	5,999	6,009	9,694
Explanation of Fund Requirements				
1. Automatic Data Processing	4,228	5,065	5,138	8,788

This funding provides for the hardware, system software, maintenance, and programming and operations support necessary to supply management with accurate and timely information. The systems supported include institutional management, finance and accounting, procurement and personnel management. The increase in the 1986 current estimate from the 1986 budget estimate provides additional contract support to upgrade the accounting system and a revised estimate of wage rates. The 1987 budget estimate includes the replacement of a critically needed administrative computer which will be capable of handling current and future demands for online systems and real-time information, as well as support contracts at anticipated wage rate levels.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
2. Scientific and Technical Information.............	595	676	676	646

These funds provide for a public affairs educational and information program, and support to the center in the provision of various scientific and technical information services. This estimate also provides for exhibit management and refurbishment, demonstration models, workshops and symposia, and education and information materials. The center is making a concerted effort to vitalize its outreach to the community. In 1985, funds supplied equipment for the briefing room which has been used for press briefings during shuttle launches and for briefings and discussions with local educators. The briefing room will be utilized to a greater extent during and following the Hubble Space Telescope mission. In 1986 and 1987, the center plans to renovate the exhibits in the Greenbelt visitors center to provide a comprehensive and participative view of the space program at GSFC.

3. Shop Support Services.........................	235	258	195	260

Support is given in the areas of safety, fire protection system maintenance and related supplies and equipment. Engineering and fabrication support for facility planning and alteration and safety, reliability, and quality assurance requirements and other technical services are included in this category. The decrease from the 1986 budget estimate to the 1986 current estimate reflects the deferral of purchases of audio visual and fire warning system equipment until 1987.

C. Management and Operations.........................	12,657	11,399	11,094	12,069

Summary of Fund Requirements

1. Administrative Communications.................	4,845	4,815	5,198	4,627
2. Printing and Reproduction.....................	5	70	61	69
3. Transportation................................	1,326	2,628	1,303	1,633
4. Installation Common Services..................	6,481	3,886	4,532	5,740
Total, Management and Operations............	12,657	11,399	11,094	12,069

(Thousands of Dollars)

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications	4,845	4,815	5,198	4,627

These funds support local telephone service, long distance service and other administrative communications. Cost increase from the 1986 budget estimate to the 1986 current estimate is due to a projected increase in Federal Telecommunications System (FTS) charges. In 1986, the center is installing its own interconnect phone system from which we anticipate annual cost savings beginning in 1987 due to reduced charges for leased lines and system maintenance.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Printing and Reproduction	5	70	61	69

This category covers the costs associated with the maintenance of administrative copiers across the center. The projected decrease from the 1986 budget estimate to the 1986 current estimate reflects anticipated cost for centerwide maintenance service agreements. The increase in the 1987 budget estimate is for anticipated rate increases in the maintenance agreements.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
3. Transportation	1,326	2,628	1,303	1,633

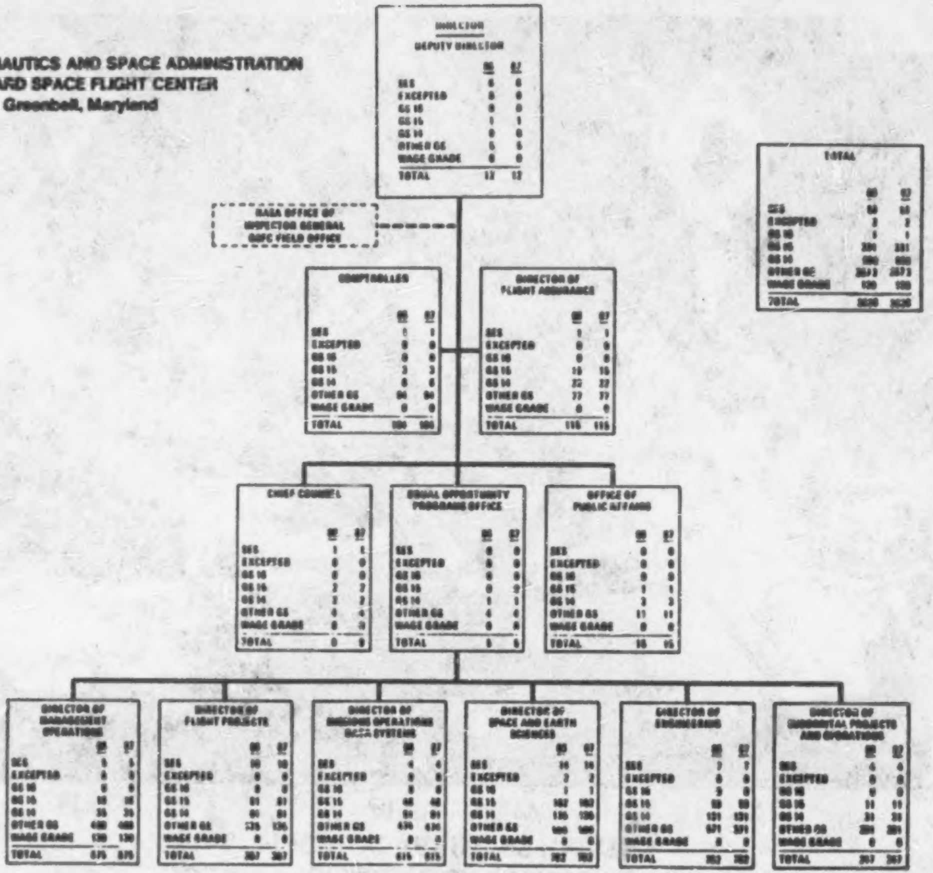
This funding provides for the operation and maintenance of an administrative aircraft, purchase of replacement vehicles, the maintenance and repair of the installation's vehicle fleet, fuel and supplies associated with the operations of the vehicles, and special vehicle rental. The decrease from the 1986 budget estimate reflects the reclassification of contract workyears associated with logistics to the installation common services subfunction. The increase in the 1987 budget estimate reflects anticipated support contractor wage rates and price levels for other goods and services in addition to the overhaul of the engine of a King Air administrative aircraft.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
4. Installation Common Services	6,481	3,886	4,532	5,740

This activity supports center management and staff activities, provides medical services, and covers various installation support services. Funding provides for costs of: patent searches and applications; materials, equipment maintenance (microfilm, special typewriters, etc.) for staff offices; operation of the GSFC on-site health unit and medical services for the Goddard Institute for Space Studies employees in New York; and emergency care on-site, annual physical exams for Goddard employees, fitness programs, immunizations and counseling. Annual physical exams are provided for approximately 3,600 employees at the center. The necessary supplies, materials, and equipment for operation of the health unit are included.

This category also provides funding for packing and crating; rigging equipment for shipment; storage and warehousing; and moving and hauling. The change from the 1986 budget estimate to the 1986 current estimate reflects the reclassification of contract workyears associated with the logistics subfunction from the transportation subfunction and the rephasing of support service contract obligations plans. The increase from the 1986 current estimate to the 1987 budget estimate reflects anticipated support service contractor wage rates, expected 1987 price levels for supplies, materials, equipment and other contractual effort, and the full year funding of support service contracts.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland


DIRECTOR
DEPUTY DIRECTOR
NASA OFFICE OF INSPECTOR GENERAL GSFC FIELD OFFICE
COMPTROLLER
DIRECTOR OF FLIGHT ASSURANCE
CHIEF COUNSEL
EQUAL OPPORTUNITY PROGRAMS OFFICE
OFFICE OF PUBLIC AFFAIRS
DIRECTOR OF MANAGEMENT OPERATIONS
DIRECTOR OF FLIGHT PROJECTS
DIRECTOR OF MISSION OPERATIONS AND DATA SYSTEMS
DIRECTOR OF SPACE AND EARTH SCIENCES
DIRECTOR OF ENGINEERING
DIRECTOR OF SUBORBITAL PROJECTS AND OPERATIONS
TOTAL
86
87
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GS 15
GS 14
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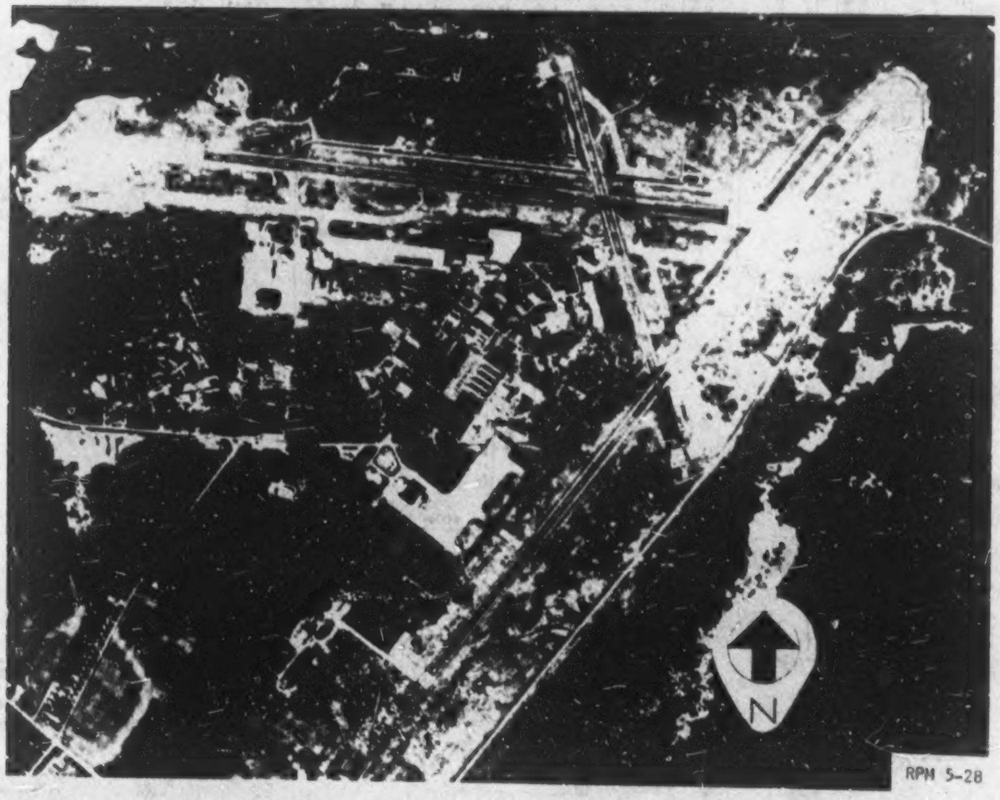
WAGE GRADE
TOTAL

RPM 5-27

GODDARD SPACE FLIGHT CENTER/WALLOPS
FISCAL YEAR 1987 ESTIMATES
AERIAL VIEW



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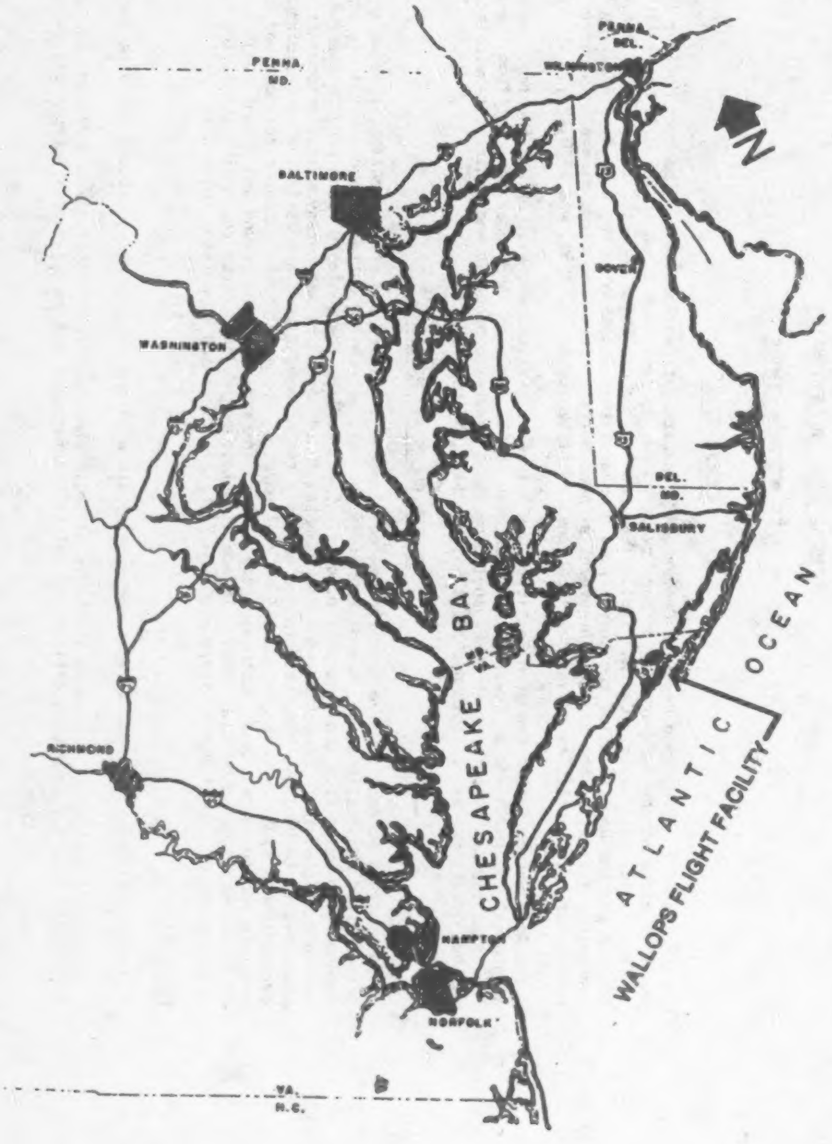
GODDARD SPACE FLIGHT CENTER/WALLOPS
FISCAL YEAR 1987 ESTIMATES
AREA MAP


PENNA.
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WASHINGTON
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DEL.
MD.
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BAY
CHESAPEAKE
OCEAN
ATLANTIC
WALLOPS FLIGHT FACILITY
RICHMOND
HAMPTON
NORFOLK
VA.
N.C.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987 ESTIMATES

AMES RESEARCH CENTER

DESCRIPTION

Established in 1940, Ames Research Center (ARC) operates at two locations. The Ames Moffett location is on 423.5 acres at the southern end of San Francisco Bay on land contiguous to the U.S. Naval Air Station, Moffett Field, California. Certain facilities, such as the utilities and airfield runways, are used jointly by NASA and the Department of the Navy. Also housed at this location is the U.S. Army Aviation Research and Technology Activity. The capital investment at Ames Moffett, including fixed assets in progress and contractor-held facilities at various locations, as of September 30, 1985, was $730,293,000.

The Ames Dryden Flight Research Facility (DFRF) is 65 air miles northeast of Los Angeles. Ames Dryden is located at the north end of Edwards Air Force Base on 521 acres of land under a permit from the Air Force. The total capital investment at DFRF, including fixed assets in progress and contractor-held facilities at various locations, as of September 30, 1985, was $125,158,000.

CENTER ROLES AND MISSIONS

The programs at Ames involve research and development in the fields of aeronautics, life sciences, space sciences and applications, and space technology, as well as use for national needs of the new science and technology growing from the aerospace program. Specifically, the Center's major program responsibilities are concentrated in: theoretical and experimental fluid mechanics and aerodynamics, rotorcraft technology, powered-lift technology, high performance aircraft technology, flight simulation, flight research, computational fluid dynamics, fluid and thermal physics, space sciences, airborne sciences and applications, controls and guidance, human factors, space biology and medicine, and ground and flight projects in support of aeronautics and space technology. In addition to these major program responsibilities, the Center provides major support for military programs. The principal and supporting roles are:

PRINCIPAL

Fundamental Aerodynamics - advance the general state of the art, both theoretical and experimental.

Rotorcraft Technology - advance the tools of helicopter performance analysis and design, and develop a technology base for improving efficiency, safety, performance and environmental acceptability.

Low-Speed Vehicle Systems - conduct research in the short and vertical takeoff and landing area with emphasis on advanced rotorcraft technology and systems.

Computational Fluid Dynamics - advance the state of the art through the definition of new systems, both hardware and software, and apply these advances to aeronautical and other related areas.

Aeronautical Flight Research - conduct flight research using aircraft as test facilities and conduct flight research programs of advanced aerospace vehicle concepts.

Flight Test Techniques - investigate and develop new flight test techniques to improve the capability of conducting flight research.

Flight Instrumentation Development - direct the development of new methods and equipment for flight measurements.

Guidance and Control - conduct theoretical investigation, simulation and flight research evaluation of new and innovative concepts in rotorcraft and power-lift aircraft flight control to validate design methods and verify system performance in the flight environment.

Human-Vehicle Interactions - advance the state-of-the-art through the study of man-machine and other human factor interactions and considerations involved in aircraft operations.

High-Speed Aircraft - conduct flight research on advanced military configurations and demonstrate the potential for improved aircraft performance through the integration of aircraft systems.

Aircraft Automation - develop a technology base for automated aircraft by conducting research in the integration of artificial intelligence, controls and human factors.

Short Takeoff and Vertical Landing (STOVL) Technology - develop a technology base for military STOVL systems in support of Department of Defense missions.

Materials and Structures - conduct tests to increase the understanding of structural responses to aerodynamic heating, with particular emphasis on high temperature space or hypersonic vehicle structures.

Flight Simulation - improve the state of the art to permit more effective use of simulators in aircraft design and validation-of-flight simulation; provide support to NASA and other government agencies' development and flight programs.

Military and FAA Aeronautics - provide facilities and technical support to military and civil aviation in areas consistent with other Ames aeronautics roles and unique capabilities.

Transatmospheric Research and Technology - combine aeronautics and space disciplines to provide the technology for a future class of vehicles capable of flight to orbit and/or hypersonic cruise.

Airborne Research and Applications - conduct airborne research and applications experiments by operating instrumented jet aircraft.

Information Sciences - advance the nation's automation capabilities by focusing research efforts on the technology development for support of space station, planetary, astrophysical and aeronautical missions, and commercial use of space.

Fluid and Thermal Physics - develop thermal analysis methods and thermal protection systems required for aerospace planes and orbital transfer vehicles, including probe development for the Galileo mission.

Planetary Mission Operations and Data Analysis - conduct mission operations and data analysis support for the Pioneer series of missions.

Physics and Astronomy - conduct research in infrared astronomy, atmospheric physics, and astrophysics to contribute to basic understanding of the planet Earth.

Life Sciences:

Life Support Systems - develop advanced technology for spacecraft life support systems and protective systems.

Life Sciences Spaceflight Experiments - develop, manage and operate spaceflight experiments in the life sciences, particularly those involving non-human species, and provide information applicable to solving space medicine problems.

Space Biology - utilize the unique environment of space to expand our understanding of basic biological phenomena.

Biomedical Research - understand and ameliorate biomedical problems experienced by man during and following spaceflight.

Life in the Universe - provide understanding of the origin, evolution, nature and distribution of life in the universe and understand its interaction with the terrestrial environment.

SUPPORTING

Space Transportation System - provide prime and contingency landing support to the Space Transportation System.

Advanced Turboprop - Conduct research and technology efforts including wind tunnel and flight tests to support NASA's efforts in advanced turboprop technology.

SUMMARY OF RESOURCES REQUIREMENTS

Funding Plan by Function

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs.............	93,439	93,756	94,564	96,698
II. Travel..................................	2,513	2,720	2,717	2,983
III. Operation of Installation	24,338	31,516	27,417	34,232
A. Facilities Services	(11,796)	(18,757)	(15,861)	(21,820)
B. Technical Services	(3,944)	(4,924)	(3,721)	(4,186)
C. Management and Operations	(8,598)	(7,835)	(7,835)	(8,226)
Total, fund requirements	120,290	127,992	124,698	133,913

Distribution of Permanent Civil Service Workyears

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
RESEARCH AND DEVELOPMENT	1,459	1,444	1,458	1,458
Space Station	12	14	11	11
Space Science and Applications	340	333	336	336
Physics and astronomy	107	111	105	105
Life sciences	132	127	133	133
Planetary exploration	54	47	47	47
Space applications	47	48	51	51
Commercial Programs	4	5	4	4
Technology Utilization	2	3	2	2
Commercial Use of Space	2	2	2	2
Aeronautics and Space Technology	1,103	1,092	1,107	1,107
Aeronautical Research and Technology	953	958	953	919
Transatmospheric Research and Technology	--	--	--	50
Space Research and Technology	150	134	154	138
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	75	75	71	71
Space Transportation Operations	40	40	36	36
Space and Ground Network Communications and Data Systems	35	35	35	35
Subtotal, direct workyears	1,534	1,519	1,529	1,529
CENTER MANAGEMENT AND OPERATIONS	510	482	500	500
Total, permanent workyears	2,044	2,001	2,029	2,029
Other than full-time	128	113	115	115
Total, workyears	2,172	2,114	2,144	2,144

PROGRAM DESCRIPTION

RESEARCH AND DEVELOPMENT	Permanent Civil Service Workyears
SPACE STATION..	11

Space Station efforts will consist of definition and integration studies and advanced technology development activities with special emphasis on plant and animal life sciences experiments and equipment, human factors design criteria, and information sciences and support functions.

PHYSICS AND ASTRONOMY	105

In 1987, the civil service personnel will provide support for the airborne astronomy program, which includes a C-141 aircraft, the Kuiper Airborne Observatory, and a Lear Jet aircraft, which are operated by Ames as flying astronomical observatories with the bulk of the observing accomplished by various university research teams. These facilities are supported through in-house research in astronomy and astrophysics and with in-house capability to operate research aircraft. The Center controls a variety of other operational aircraft, including two U-2C's, an ER-2, and a C-130, some of which serve as unique national and international facilities for research in astronomy, geophysics, meteorology, and Earth resources; others acquire data for remote sensing projects and provide a mechanism for integration of spaceborne, airborne, and ground-based data acquisition and processing systems. Support for the astronomy program is also provided by a sophisticated laboratory effort in spectroscopy and dust physics.

Infrared astronomy observation from space platforms avoids obscuration caused by the Earth's atmosphere. Ames has the responsibility for definition and development of instruments to accomplish these observations, which have included such developments as the telescope portion of the Infrared Astronomical Satellite, launched in early 1983; definition of the Space Infrared Telescope Facility and definition studies of instruments to be used on potential free flyers in space.

Ames has an active program of laboratory, theoretical and computational studies to develop the basic astrophysical modeling concepts, to obtain the necessary physical data, to interpret the infrared astronomical observations, and to support the development of improved scientific instrument concepts for use on aircraft and spacecraft. This program's objectives are to investigate the nature and evolution of solar systems; and to investigate galactic and extragalactic objects through the unique insights to be gained by infrared observations of these astrophysical systems.

Permanent Civil
Service Workyears

LIFE SCIENCES.. 133

In 1987, the civil service personnel will continue to be involved in research, hardware development, and program management related to meeting program milestones in the areas of understanding the effects of space flight on humans and other life forms, managing non-human biological experiments in space, and understanding the origin, evolution, and distribution of life and life-related chemicals on Earth and elsewhere in the universe.

Biomedical research will be conducted to investigate the effects of space flight on humans. Specifically, causes and potential countermeasures for neurophysiological, musculo-skeletal, and cardiovascular changes observed during and immediately following space flight will continue to be studied. Ground-based space flight simulations and actual flight experiments with humans and animals will continue to be performed to provide a basis for understanding why and how biological systems are affected by space flight.

Spacelab Life Sciences - 1 (SLS-1), NASA's first dedicated life sciences mission, will be launched in early 1987. During this mission Ames will test a small mass measuring device, a rodent cage and the General Purpose Work Station which will permit the handling of tissues and fluids in zero gravity. Ames will also participate in the International Microgravity Laboratory - 1 (IML-1), a mission which will contain four Ames-developed experiments, one plant study and three to be housed in the ESA-built Biorack. In addition to the actual launches, Ames will continue the development and integration of experiments for the SLS-2 and the Spacelab-J missions scheduled for 1988.

Research into the origin and distribution of life and life-related molecules will also be continued through analyses of biochemical pathways in living systems, and analyses of chemical abundances in precambrian deposits by the use of an ultrasensitive stable isotope measuring system and studies of the interactions of known polypeptides and DNA segments. Research efforts in the origin and distribution of biogenic elements will increase. Cometary particles collected by U-2 aircraft will be analyzed for carbon abundance, phase, and molecular identification.

The Ecosystems Science and Technology Program will continue to enhance the understanding of the biological aspects of global conditions and biogeochemical processes on Earth. Progress will be achieved through investigations in remote sensing science and advanced sensor technology; dieciplinary research in areas of plant stress, hydrologic cycles, and forest biomass determinations. Interdisciplinary research will include biogeochemical cycles and ecosystem disturbances. These latter two research areas involve not only remote sensing, but theoretical and experimental work within the disciplines of (1) biology, (2) biochemistry, (3) atmospheric science, (4) geochemistry, and (5) spectroscopy.

Permanent Civil
Service Workyears

PLANETARY EXPLORATION 47

A continuing series of project management activities, backed by the scientific expertise of principal investigators from Ames, other NASA Centers and the university community, will be continued in 1987 to accomplish the ongoing programs in planetary exploration. An in-house supporting research and technology program serves both to maintain the Center's scientific and technological expertise and to provide the stimulus and definition for new planetary research.

In 1987, the civil service personnel will continue to provide project management and scientific support for Pioneers 6 through 9, a series of spacecraft exploring the physics of the interplanetary medium and providing ongoing data on the plasma in which the Earth is immersed; Pioneers 10 and 11, two spacecraft that made close approaches to the planet Jupiter to study the planet and its magnetic field; Pioneer Venus Orbiter which is still taking data at Venus and which will examine Halley's Comet in the UV during perihelion passage; and the Galileo Probe which will investigate the atmosphere of Jupiter and its environment.

Ames researchers are playing a key role in these missions. Ames scientists are responsible, as principal investigators, for measuring the characteristics of the solar wind in the interplanetary space and near Jupiter and Saturn; measuring the atmospheric structures on Mars, Venus and Jupiter; measuring atmospheric radiation balance and cloud characteristics on Venus and Jupiter; studying Mars for possible life-bearing soils and compounds; and investigating planetary ring systems as observed by spacecraft and other techniques. Ames researchers are also responsible for synthesizing atmospheric models of these planets that can be used to explain their current state and evolution and be applied in comparative studies to understand features of the Earth's climate.

Ames maintains an active program of laboratory, computational, and theoretical studies to develop basic atmospheric modeling concepts, obtain the necessary physical data to interpret the spacecraft observations, and develop improved scientific measurements and instrument concepts for use on spacecraft. This program concentrates on planetary atmospheres and has been particularly active in combining radiative transfer concepts with aerosol physics to obtain comprehensive planetary cloud and dust models.

SPACE APPLICATIONS.. 51

A highly diversified group of scientists, engineers, and technicians are required in 1987 to support programs in Earth and environmental observations including space, atmospheric, and stratospheric programs;

to provide skilled personnel in support of the Agency's applications satellite programs; to interpret and process both spaceborne and airborne remotely sensed data; and to interact with and disseminate data and associated processing techniques to the user community.

The Ames atmospheric research program is an integrated activity that blends the expertise of the Center personnel and university scientists, in the development of computer models for the atmosphere and in the measurement of atmospheric constituents and properties from aircraft platforms. Computer modeling of the atmosphere is being performed to understand the atmosphere and predict the effects of various pollutants, such as aircraft emissions and fluorocarbons, and of natural events such as the solar cycle, solar storms and volcanic eruptions. These modeling efforts make effective use of the unique computational resources at the Center. A similar program which focuses on the climatic effects of aerosol and cloud particles in the Earth's atmosphere through models of aerosols and their radiative effects and through measurements of aerosol and cloud properties from aircraft is also underway at Ames.

Ames space applications responsibility is also fulfilled by conducting a continuing program of applied research and development to enhance the use of remote and in-situ sensing technology for Earth resources applications and defining, developing, and evaluating potential future satellite sensors, data acquisition and processing techniques, and associated communications technology.

	Permanent Civil Service Workyears
TECHNOLOGY UTILIZATION..	2

The technoglogy utilization program serves to transfer knowledge developed through the NASA programs into industry for effective use in the marketplace.

COMMERCIAL USE OF SPACE	2

The objective of the Commercial Use of Space program is to increase private sector awareness of space opportunities and encourage increased industry investment and participation in high technology space-based research and development. This effort will establish an organizational focal point to initiate a program specifically intended to foster commercial use of and access to space.

Permanent Civil
Service Workyears

AERONAUTICAL RESEARCH AND TECHNOLOGY 919

In 1987, the Ames program in aeronautics will be characterized in terms of three elements: generic research and technology, vehicle specific technology (e.g., rotorcraft) and aeronautical support to other government agencies and to industry. These three elements form a coherent and interdependent program to meet the objectives of rotorcraft, powered-lift and high-performance aircraft by improving operational performance and terminal-area safety and efficiency and by reducing aircraft noise and vibrations.

Generic Research and Technology:

The generic research and technology program is principally focused in the disciplines of fluid and thermal physics, propulsion, structures, flight dynamics, guidance and control, and human factors. The program provides the fundamental disciplinary advances, both theoretical and experimental, that extend the state of the art. Substantial progress is anticipated in Ames' ability to compute the theoretical behavior of flows about aerodynamic components and full configurations and to measure experimental aircraft configuration parameters. Continued efforts will be directed toward providing advances in computational capability supporting aeronautical research. Numerical aerodynamic simulation will focus on augmenting the Nation's program in computational fluid dynamics and other areas of computational physics by developing an advanced capability that will provide modern and efficient access for users nationwide for application to computational aerodynamics, computational chemistry, and other complex analytical problems. Also, fundamental aerodynamic research will be continued using large- and small-scale research facilities and flight research vehicles to develop design methodologies for designing advanced aircraft. Flight research will continue for the development of aircraft systems integration technology including flight, propulsion, and aerodynamic controls. In controls and guidance, advanced control technology will focus on: developing the methodology to design highly coupled, highly non-linear control systems; developing reliable flight-critical control systems for advanced aircraft; evaluating and improving digital flight control system prediction tools, techniques, methodology and criteria; applying optimal control theory in conjunction with dynamic modeling of aircraft and ground-based guidance aids to provide new insights into the definition of air traffic control system interfaces; and conducting flight research on digital fly-by-wire concepts to continue to support the development of advanced flight systems technology. In 1987, the human factors program will include continuation of basic research in workload and performance measurements, fundamentals of visual perception, development of helicopter and high-performance aircraft display and control integration to reduce pilot workload, study of advanced flight display formats for improving information presentation to aircrew, and more complete understanding of human fatigue and circadian desynchronosis effects on aircraft pilots. In addition, the applications of the results of these generic activities to space flight crews and hardware will be examined.

Vehicle Specific Technology:

The vehicle specific technology is focused on rotorcraft, powered-lift and high-performance aircraft. The vehicle technology emphasis at Ames relates to, and depends on, the basic capabilities and the aeronautical research disciplines described previously. The 1987 research program will include small-scale and large-scale wind tunnel testing and ground-based simulation, and flight research. Powered-lift aircraft performance is highly dependent on high-lift technology (both propulsive and aerodynamic lift) and advanced guidance and control systems, both of which are part of the ongoing program at Ames. High-performance aircraft research requirements include the areas of high angle-of-attack performance and control, sophisticated flight and aerodynamic controls, structural, aerodynamic, flight control and propulsive system interactions, and superaugmented aircraft. In rotorcraft aerodynamics, research will be conducted to improve the understanding of rotor aerodynamics, rotor/fuselage interaction. In guidance, work will be pursued to improve all-weather rotorcraft capability for terminal area operations. In the controls area, flying qualities design criteria will be developed to improve control system concepts for better performance and mission capabilities for rotorcraft. In addition, efforts will be continued to investigate the requirements for flying night, all-weather, nap-of-the-earth missions with a single pilot. Research to provide major improvements in aircraft automation will be conducted through the use of artificial intelligence. In 1987, technology for next-generation rotorcraft will pursue further understanding relative to high-speed rotorcraft concepts and will continue preparation for flight research on the X-wing.

Other Aeronautical Support:

Ames has traditionally received requests from other agencies and industry, as well as from other NASA centers, for test support of their aircraft and systems development programs. Typically, Ames provides 8,000 to 9,000 hours per year of wind tunnel occupancy time in support of both commercial and military aircraft development, as well as support for large NASA projects such as the Space Shuttle. The Research and Technology Directorate of the U.S. Army Aviation Research and Development activity, and the Aero Flight Dynamics Directorate, both under Aviation Systems Command (AUSCOM) are located at Ames. The Aero Flight Dynamics Directorate, the primary investigator of Army rotorcraft flight dynamics and controls, is also located at Ames, working both on independent research and development projects and with a staff integrated into the NASA organization on projects of joint interest. Extensive use is made of Ames aeronautical research facilities in these efforts.

There are also a large number of joint programs with the Air Force Systems Command, the Naval Air Systems Command, and the Defense Advanced Research Projects Agency (DARPA). Examples of these joint efforts include: (1) V/STOL and STOVL fighter studies, JVX support, LHX support and an AV-8B flight test program with the Navy; (2) participation in the joint NASA/DARPA X-29A forward swept wing demonstration programs; (3) continued participation in the joint NASA/USAF Advanced Fighter Technology Integration (AFTI) F-111 program for research and development of a mission adaptive wing that will obtain smooth in-flight contour changes to the wing aerodynamic shape to achieve improved aerodynamic efficiency; (4) continued participation in the joint NASA/USAF AFTI/F-16 program using a digital flight control system for conventional and nonconventional control without degrading overall performance; (5) continued participation with the Navy in a program to extend oblique wing technology to transonic and supersonic speeds; and(6)work on digital flight control system verification and validation with the FAA. Advanced structural, aerodynamic, propulsion, and control concepts will be investigated. In conjunction with the DARPA, a large-scale flight investigation of the X-wing rotor system will be conducted, utilizing the rotor systems research aircraft. The focus will be in exploring the start-stop phase of flight for the high-speed X-wing concept.

	Permanent Civil Service Workyears
TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY..	50

The activities at ARC are in two major areas. The first emphasizes the special capabilities and expertise in hypersonic and computational facilities at Ames Moffett for the conduct of extremely high Mach number tests and analysis of both wind tunnel and flight data. The strength of the computational methods using the Class VI and numerical aerodynamic simulation computers, combined with the advanced materials activities, provides unique capabilities to design and tailor lightweight, high-temperature structures applicable to advanced hypersonic cruise and aerospace vehicle concepts. The second area emphasizes the special capabilities at Ames Dryden to evolve the testing, instrumentation, data acquisition systems, and range capabilities necessary for future potential flight testing of a hypersonic/transatmospheric research vehicle over the required range of speed, altitude and envelope conditions.

SPACE RESEARCH AND TECHNOLOGY..	138

In 1987, civil service personnel will provide a space research and technology program which encompasses both basic research and project support. The basic research focuses on entry technology and materials research, with a germinal effort in artificial intelligence. The project work supports space shuttle, the orbiter experiments program, the infrared astronomy program, the Galileo probe, and advanced work related to technology definition of a space station.

The entry technology research will provide aerothermodynamic data required for the design, development, and verification of planetary entry vehicles; aero-assisted orbital transfer vehicles (AOTV), and computational fluid dynamic codes to predict space vehicle flow fields and performance. Work is proceeding to apply laser physics and nonintrusive laser techniques to the development of flow diagnostic tools that will be used to probe gas dynamic flows that will in turn be used to define and verify turbulence models. Research efforts in the materials area will provide advanced thermal protection systems concepts and materials for heat shields to protect Earth and planetary entry vehicles (probes) and AOTV's; develop computational chemistry codes to calculate basic properties of matter; and expand the understanding of surface environment interactions (corrosion). Research is also being conducted in the advanced electronics and materials areas to determine atomic structure and properties of absorbed surface layers and to advance the state of the art of computing wave functions for molecules and atomic clusters. Research in artificial intelligence will address spaceborne symbolic processing, information extraction, and software tools for development of knowledge-based systems.

In 1987, the Space Shuttle program will be used along with ground-based facilities to study a variety of aerodynamic and thermodynamic problems. The Galileo project will be supported with heat shield design and performance data, heat shield shape change effects on aerodynamics, and subsonic probe stability. Ground-based facilities will also simulate AOTV heating environments and debris-impact on space station components. In the area of orbiting astronomical instruments, work will continue to develop infrared detectors, define systems for precision pointing and control of telescopes, and advance the technology required to cool detectors to very low temperatures. Ames is supporting space shuttle orbiter experiments to study advanced materials and evaluate possible cost and weight reduction for the thermal protection system for shuttle and advanced space transportation systems.

Ames work will be directed primarily toward developing and conducting selected space shuttle experiments and performing disciplinary research in the high-temperature space structures technology area.

The shuttle experiments include: continuation of simulation studies to assist in analysis and solution of various problems that exist in certain flight profile areas between entry and landing and evaluation of the performance of the shuttle entry air data system; studies to evaluate adequacy and provide a basis for improving shuttle handling qualities criteria; and application of modified maximum likelihood parameter estimation methods for determination of digital flight control systems, stability and control, performance, and structural and atmospheric turbulence characteristics in the shuttle reentry environment.

High-temperature space structures disciplinary research will involve analyses and laboratory tests of medium-sized specimens to evaluate predictive techniques for thermal structures. Also, airloads data will be obtained from calibrated strain gauges on the orbiter and compared with wind tunnel and theoretical predictions to evaluate flight measurement techniques and analytical methods.

The infrared astronomy program is technologically supported in three primary areas: infrared detector research, cryogenics, and optics. This technology research is developing techniques for measuring infrared sensitivity and bandwidth to provide much-enhanced data for scientific research. Specific work consists of developing detector arrays and electronics, lightweight mirrors and optics, structures, and cryogenic systems including replenishable systems.

Permanent Civil
Service Workyears

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

SPACE TRANSPORTATION OPERATIONS.. 36

Dryden Flight Research Facility is the secondary recovery site for the Space Shuttle Program and the primary recovery site for selected missions. DFRF also must be in a recovery mode for every launch in case the Space Shuttle must abort on the first orbit. Upon landing, DFRF provides orbiter convoy operations support, support in deservicing the orbiter, in mating the orbiter to the Shuttle Carrier Aircraft for transporting the orbiter to Kennedy Space Center. DFRF is also responsible for maintaining the Space Shuttle servicing facilities located at Ames Dryden.

SPACE AND GROUND NETWORK COMMUNICATIONS AND DATA SYSTEMS............................ 35

In 1987, DFRF will maintain and operate the NASA Western Aeronautical Test Range, which provides direct operational support for a wide variety of aeronautical and aerospace programs. During real-time mission support operations, the various functional elements such as radar, tracking and data processing, communications, airborne video acquisition, and telemetry data processing all function in an intergrated manner in the range Mission Control Centers to provide real-time control, monitoring, processing and command uplink capabilities. Post-mission processing is also supplied as support to programs short of the analysis or second generation data processing function.

CENTER MANAGEMENT AND OPERATIONS SUPPORT.. 500

Center Management and Operations Support is support or services that are provided to all Ames organizations which cannot be identified exclusively to a single program or project. The civil service personnel involved are as follows:

Director and Staff - The Center Director, Deputy Director, Associate Director, and the immediate staff, e.g., Chief Counsel, Patent Counsel, Equal Opportunity, Public Affairs, Resources Management, and under the auspices of the Chief Engineer, Health, Safety, Security and Energy Management.

Management Support - The part of the Ames civil service workforce which provides information and control services supporting all levels of Center management, both program and functional. Specific functions include financial management, contracting and procurement, property management, and personnel management.

Operations Support - The part of the Ames civil service workforce which provides for the operation and maintenance of institutional facilities, buildings, systems, and equipment, and which provides technical services such as administrative automatic data processing, library and information services.

RESOURCE REQUIREMENTS BY FUNCTION

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
I. PERSONNEL AND RELATED COSTS.................	93,439	93,756	94,564	96,698
Summary of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Full-time permanent workyears.......	77,448	78,281	78,002	78,950
b. Other than full-time permanent......	2,704	2,662	2,693	2,693
c. Reimbursable detailees..............	391	378	671	899
d. Overtime and other compensation.....	1,588	1,534	1,637	1,637
Subtotal, Compensation..............	82,131	82,855	83,003	84,179
2. Benefits................................	9,770	9,816	9,978	10,399
Subtotal, Compensation and Benefits...	91,901	92,671	92,981	94,578
B. Supporting Costs				
1. Transfer of personnel..................	430	166	457	477
2. Personnel training......................	1,108	919	1,126	1,643
Subtotal, Supporting Costs............	1,538	1,085	1,583	2,120
Total, Personnel and Related Costs......	93,439	93,756	94,564	96,698

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
A. Compensation and Benefits..................	1,901	92,671	92,981	94,578
1. Compensation..........................	82,131	82,855	83,003	84,179
a. Full-time permanent workyears.......	77,448	78,281	78,002	78,950

The decrease from the 1986 budget estimate to the 1986 current estimate is due to a revised allocation of FTE's.

Basis of Cost for Permanent Workyears

In 1987, the cost of permanent workyears will be $78,950,000. The increase from 1986 is calculated as follows:

Cost of full-time permanent workyears in 1986...............................		78,002
Cost Increases in 1987...		2,020
Within grade and career advances:		
Full year cost of 1986 actions.................................	875	
Partial year cost of 1987 actions..............................	1,145	
Cost Decreases in 1987...		-1,072
Turnover savings and abolished positions:		
Full year cost of 1986 actions................................	-405	
Part year cost of 1987 actions................................	-667	
Cost of full-time permanent workyears in 1987................................		78,950

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
b. Other than full-time permanent				
1. Cost.............................	2,704	2,662	2,693	2,693
2. Workyears........................	161	161	163	163

The distribution of 1987 workyears is as follows:

Distribution of Other Than Full-time Permanent Workyears

Program	Workyears
Development programs..	60
Summer employment program..	11
Youth opportunity programs...	48
Other temporary..	44
Total..	163

The current estimate for 1986 reflects an increase from the 1986 budget estimate due to an increase in workyears.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
c. Reimbursable detailees..............	391	378	671	899

The military personnel detailed to Ames on a reimbursable basis are individuals experienced in aeronautics, rotorcraft technology, veterinary medicine, and related fields. The increase in the 1986 current estimate and the 1987 budget estimate are due to including military retirement costs in detailee reimbursements.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
d. Overtime and other compensation.......	1,588	1,534	1,637	1,637

Overtime and other compensation includes overtime, holiday pay, incentive awards, Sunday premium pay, and night work differential. The use of overtime and other compensation is primarily for off-peak operation of major facilities such as the Unitary Plan Wind Tunnel System, and the 6-by-6 foot Supersonic Wind Tunnel, and preparation for test flights and Space Shuttle operations. The increase from the 1986 budget estimate to the 1986 current estimate is due to additional overtime requirements for the 40-by-80-by-120 Foot Wind Tunnel Project and five shuttle landings at Dryden.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Benefits	9,770	9,816	9,978	10,399

The following are the amounts of contributions by category:

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Civil Service Retirement Fund	5,510	5,243	5,283	5,068
Employee Life Insurance	186	214	194	200
Employee Health Insurance	2,165	2,317	2,252	2,327
Workmen's Compensation	624	623	624	765
FICA	407	508	715	1,109
Medicare	878	911	910	930
Total	9,770	9,816	9,978	10,399

The increase from the 1986 budget estimate to the 1986 current estimate reflects increased costs associated with FICA for new employees. The 1987 budget increase reflects an increase in FICA and Workmen's Compensation estimates based on Department of Labor billings.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Supporting Costs	1,538	1,085	1,583	2,120
1. Transfer of personnel	430	166	457	477

The increase from the 1986 budget estimate to the 1986 current estimate reflects a change in the GSA policy regarding payment for PCS moves and household goods. The 1987 budget estimate reflects expected increased cost rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Personnel training	1,108	919	1,126	1,643

The increase from the 1986 budget estimate to the 1986 current estimate reflects 1985 experience. The increase from the 1986 current estimate to the 1987 budget estimate is due to increased training for new technical employees at anticipated tuition cost levels.

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
II. TRAVEL	2,513	2,720	2,717	2,983

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	1,521	1,816	1,830	2,058
B. Scientific and Technical Development Travel	486	450	433	448
C. Management and Operations Travel	506	454	454	477
Total, Travel	2,513	2,720	2,717	2,983

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	1,521	1,816	1,830	2,058

Program travel is required for the accomplishment of the Center's missions and accounts for 69 percent of travel costs in 1987. Travel for program purposes is required for the continuing efforts in space research, aeronautical research and technology, flight simulation, fluid mechanics, airborne research and applications, space life sciences, flight test techniques, flight measurements, guidance and flight control, and flight measurement development activities. The increase from the 1986 budget estimate to the 1986 current estimate is due to life sciences flight experiments. The latter is in support of Spacelab flights on the shuttle. The 1987 estimate primarily provides for anticipated rate increases.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Scientific and Technical Development Travel	486	450	433	448

Scientific and technical development travel permits employees to participate in meetings and technical seminars with other representatives of the scientific and aerospace community. This participation allows them to benefit from exposure to technological advances outside Ames as well as to present both accomplishments and problems to their associates. Many such meetings are working panels convened to solve certain problems for the benefit of the Government. The decrease from the 1986 budget estimate to the 1986 current estimate reflects a lower number of trips. The 1987 estimate reflects approximately the same level of activity as in 1986.

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
C. Management and Operations Travel.................	506	454	454	477

Management and operations travel provides for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management and procurement; travel of the Center's top management to NASA Headquarters, other NASA Centers, and contractor plants; and local transportation. The 1987 estimate reflects the 1986 level of travel at anticipated rate levels.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
III. OPERATION OF INSTALLATION........................	24,338	31,516	27,417	34,232

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Facilities Services..........................	11,796	18,757	15,861	21,820
B. Technical Services...........................	3,944	4,924	3,721	4,186
C. Management and Operations....................	8,598	7,835	7,835	8,226
Total, Operation of Installation...........	24,338	31,516	27,417	34,232

Explanation of Fund Requirements

Operation of Installation provides a broad range of services, supplies, and equipment in support of the center's institutional activities. These are divided into three major functional areas: Facilities Services, the cost of maintaining and repairing institutional facilities and equipment, and the cost of custodial services and utilities; Technical Services, the cost of automatic data processing for management activities, and the cost of educational and informational programs and technical shops supporting institutional activities; and Management and Operations, the cost of administrative communications, printing, transportation, medical, supply, and related services.

The reduction from the 1986 budget estimate to the 1986 current estimate is primarily due to delay and deferral of activities, and lower than anticipated electricity and support contractor wage rates. The 1987 estimate provides for expected rate increases in support contractor wages and anticipated utility wage commensurate with planned program activities.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. FACILITIES SERVICES................................	11,796	18,757	15,861	21,820

Ames includes 11 major technical facilities. This physical plant supports an average daily population of 2,500 to 2,900 personnel. Many of the facilities are utiltzed on schedules involving more than one shift and frequently during off-peak hours. The physical plant at Dryden houses an average daily on-site population of 900 to 1,200 personnel. Many of the test facilities are also utilized on schedules involving more than one shift, which frequently operate during off-peak hours.

Summary of Fund Requirements

(Thousands of Dollars)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Rental of Real Property	48	47	43	47
2. Maintenance and Related Services	3,681	4,032	3,065	3,408
a. Facilities	3,634	3,983	3,023	3,361
b. Equipment	47	49	42	47
3. Custodial Services	3,367	4,301	3,976	4,365
4. Utility Services	4,700	10,377	8,777	14,000
Total, Facilities Services	11,796	18,757	15,861	21,820

Explanation of Fund Requirements

1. Rental of Real Property	48	47	43	47

At Dryden, this item provides for the rental of trailers to provide office, shop, laboratory, and storage space in support of the Space Shuttle program. The decrease from the 1986 budget estimate to the 1986 current estimate is due to purchase rather than rental of some of the trailers which support the Space Shuttle program. The 1987 estimate provides for the same rental space as 1986.

2. Maintenance and Related Services	3,681	4,032	3,065	3,408

At Ames, maintenance and repair includes the maintenance of grounds and emergency repairs of heating, ventilating, and lighting equipment in the institutional buildings and offices. Maintenance of grounds includes maintenance of approximately 30 acres of improved planted areas and associated pest control; maintenance of approximately 45 acres of unimproved areas such as substations, aircraft taxiways, drainage ditches, large fields and roadway shoulders within these areas; and vacuum sweeping approximately 42 acres of streets, parking lots, and aircraft ramp, taxiway and V/STOL areas. At Dryden, this activity involves all facilities, including those used for Shuttle. The reduction from the 1986 budget estimate to the 1986 current estimate reflects delay and deferral of planned maintenance activities and lower than anticipated contractor wage rates. The increase from 1986 to 1987 reflects anticipated support contractor wage rate increases and expected price levels for supplies, materials, equipment and other contractual effort.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
3. Custodial Services................................	3,367	4,301	3,976	4,365

Janitorial and building cleaning services are associated with approximately two and three quarters million square feet of various types of space located in 226 buildings and structures, and over 90 trailers which provide temporary office and shop space. Security services are for buildings and property, including aircraft and computer facilities, and "round-the-clock" staffing of an emergency duty office which monitors fire, security, and safety alarms, and coordinates fire, security, and safety areas in emergency situations. Other services included are pest control services, refuse collection, laundry and custodial supplies.

This activity involves support contractor efforts which provide janitorial and security services, fire protection and other miscellaneous custodial services and supplies. The decrease from the 1986 budget estimate to the 1986 current estimate is the result of decreases in support contractor wage rates and delay and deferral of activities to reflect budget reductions. The increase in 1987 is due to expected changes in prices for goods and services purchased.

4. Utility Services..................................	4,700	10,377	8,777	14,000

The major utility service is electricity with lesser requirements for natural gas, fuel oil, water and sewage services.

At Ames, electricity is provided by the U.S. Bureau of Reclamation's Central Valley Project, marketed by the Western Area Power Administration (WAPA) of the Department of Energy, and the Pacific Gas and Electric Company (PG&E); natural gas is provided by PG&E; water by the U.S. Naval Air Station at Moffett Field; and sewage service by the City of Mountain View.

Approximately 80 percent of the electric power at Ames Moffett is consumed in the operation of high power demand research facilities, such as the Unitary Plan wind tunnel system, the 14-foot transonic wind tunnel, and the operation of simulators and smaller wind tunnels. Approximately 55 percent of the natural gas is used in research facilities; the other part is used for heating and ventilation of institutional buildings. Ames, Moffett Field, accounts for 95 percent of the overall utility energy usage and 91 percent of total utility costs.

At Dryden utility services are purchased through Air Force contracts with regional utility companies with costs based on Air Force projected rates. The largest amount is for electricity with lesser amounts for natural gas, fuel oil, water and sewage services.

The increase between 1985 and 1986 current estimate is primarily caused by increased WAPA rates, the effect of which is less than anticipated in the 1986 budget estimate. The increase between the 1986 current estimate and the 1987 budget estimate is due to an increase in electricity consumption and rates. Rate increases are those published by WAPA, scheduled to become effective in FY 1986 and 1987, respectively.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
B. TECHNICAL SERVICES	3,944	4,924	3,721	4,186
Summary of Fund Requirements				
1. Automatic Data Processing	2,843	3,872	2,677	3,054
a. Equipment	419	1,210	180	200
b. Operations	2,424	2,662	2,497	2,854
2. Scientific and Technical Information	540	580	530	572
a. Library	89	59	64	70
b. Education and Information	451	521	466	502
3. Shop and Support Services	561	472	514	560
Total, Technical Services	3,944	4,924	3,721	4,186

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
1. Automatic Data Processing..........................	2,843	3,872	2,677	3,054

This category includes the central administrative ADP facility equipment and operating costs. The decrease from the 1986 budget estimate to the 1986 current estimate is due to delays imposed on the Center's office automation plan. The 1987 increase provides for minor, but critically needed, changes in the administrative mainframe, as well as anticipated support contractor rate increases.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Scientific and Technical Information..............	540	580	530	572

This category provides for the purchase of books, supplies, and materials for the operation of the Dryden library. Also included in this category is a support contract to perform public information services, media development, and education programs. The 1986 current estimate reflects a reduction in Shuttle public affairs requirements and decreased library costs from the 1986 budget estimate. The 1987 estimate reflects the same level as 1986 at anticipated 1987 cost rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
3. Shop and Support Services.........................	561	472	514	560

This category includes administrative shop, photo and graphics, and audiovisual services primarily supporting the public affairs activity. The increase in the 1986 current estimate and 1987 budget estimate provides for the same level of services as the 1985 actual at anticipated cost rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
C. MANAGEMENT AND OPERATIONS	8,598	7,835	7,835	8,226

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications	3,048	2,444	2,905	3,047
2. Printing and Reproduction	187	332	163	172
3. Transportation	946	898	878	924
4. Installation Common Services	4,417	4,161	3,889	4,083
Total, Management and Operations	8,598	7,835	7,835	8,226

Explanation of Fund Requirements

1. Administrative Communications	3,048	2,444	2,905	3,047

Communications services are provided by the General Services Administration (GSA) for the Federal Telecommunications Service, and the Pacific Telephone and Telegraph Company and the General Telephone and Telegraph Company for local services at Ames and Dryden, respectively. Other communications consist of teletype equipment and services provided by Western Union. Also included are the lease of switchboard equipment and the support contract for telephone operators. The increase from the 1986 budget estimate to the 1986 current estimate is due to increases in local communication costs. The 1987 estimate reflects the same level of service plus anticipated rate increases.

2. Printing and Reproduction	187	332	163	172

The estimate for administrative printing includes the operating costs of the printing and reproduction facility as well as supplies, materials, equipment acquisitions and outside procurements. All common processes of duplication, including photostating, blueprinting and microfilming are included. The decrease from the 1986 budget estimate to the 1986 current estimate reflects a reduction in the level of printing activity. The increase in the 1987 budget estimate provides for level services at anticipated rate increases.

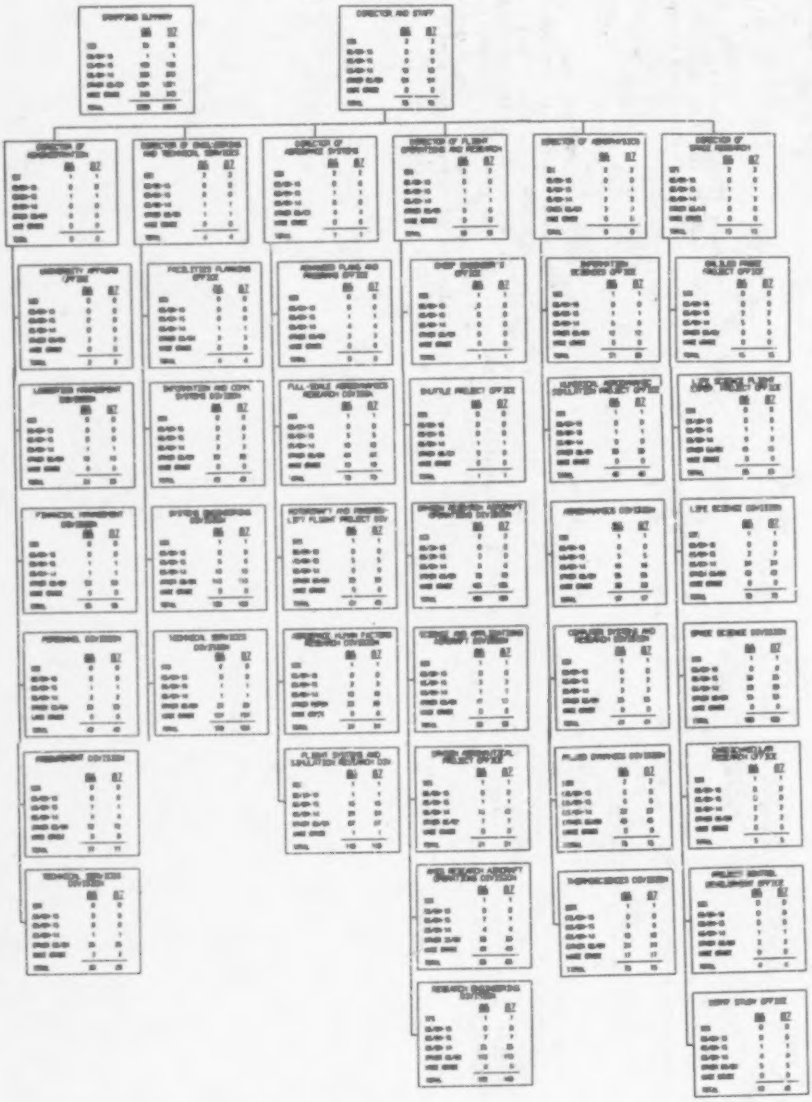
	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
3. Transportation	946	898	878	924

The estimates include motor pool operation costs including GSA vehicle rentals, freight costs, Government bills of lading, air freight and other general shipments. The reduction in the 1986 current estimate from the 1986 budget estimate is due to a decrease in support contractor rates. The 1987 budget estimate provides for the same level of service as 1986 plus anticipated rate increases.

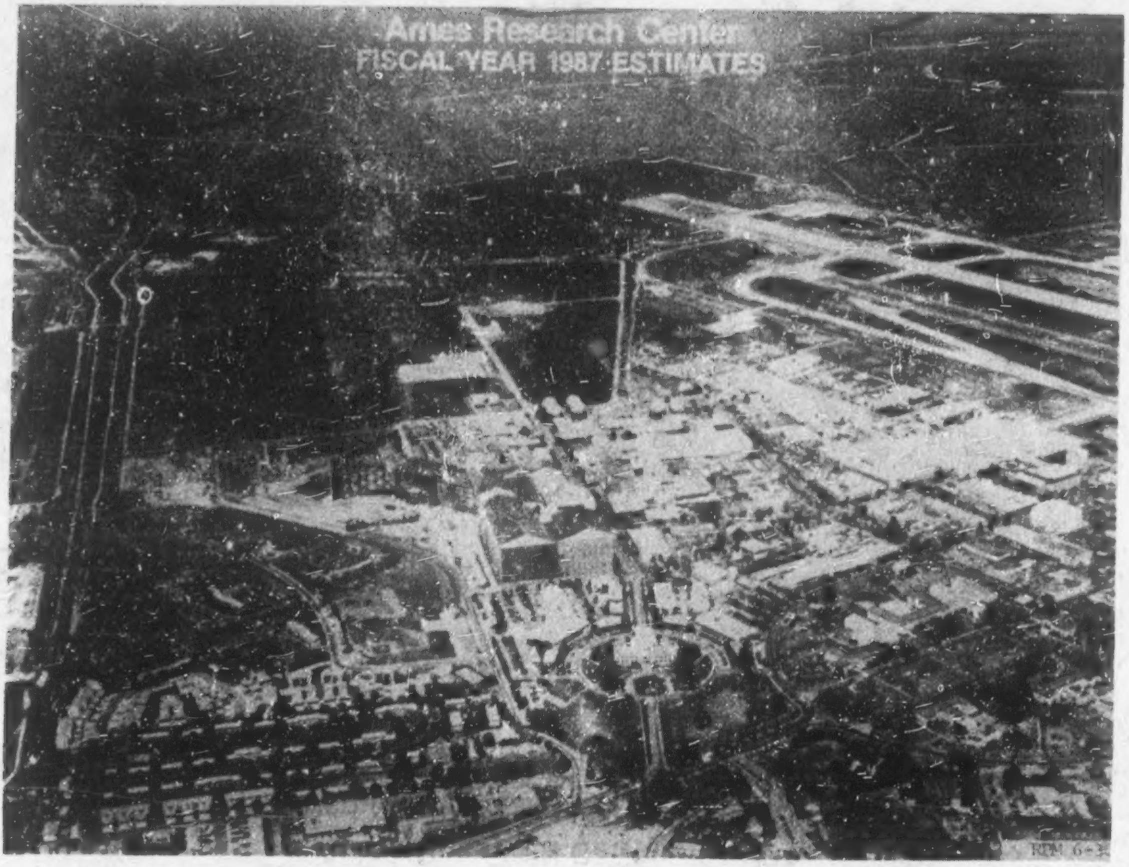
	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
4. Installation Common Services	4,417	4,161	3,889	4,083

These services include support to center management and staff activities, medical services, and installation support activities. For example, this category includes those supplies, materials and services in support of Center management, general and patent legal services, personnel, procurement, and financial management services. Medical services include the staffing of the health units, laboratory service fees, clinic supplies, and maintenance of clinic equipment. Installation support services provide contractor support for supply and property management, mail, pickup and delivery services, and postage. The decrease from the 1986 budget estimate to the 1986 current estimate is due to a reestimate of support contractor wage rates. The 1987 budget estimate provides approximately the same level of effort as in 1986.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AMES RESEARCH CENTER
ORGANIZATION AND STAFFING CHART


STAFFING SUMMARY
DIRECTOR AND STAFF
86
87
TOTAL
FACILITIES PLANNING OFFICE
INFORMATION AND COMM. SYSTEMS DIVISION
FULL-SCALE AERODYNAMICS RESEARCH DIVISION
SHUTTLE PROJECT OFFICE
LIFE SCIENCE DIVISION
PERSONNEL DIVISION
TECHNICAL SERVICES DIVISION
SPACE SCIENCE DIVISION

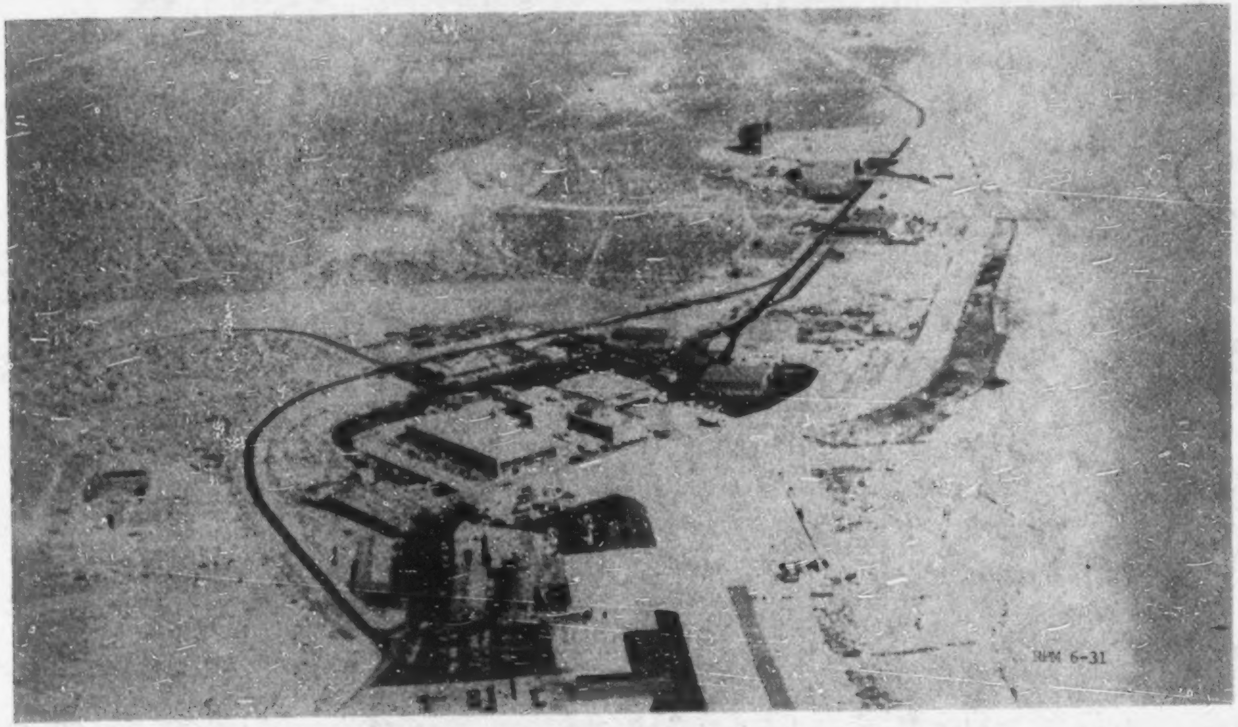
RPM 6-29


Ames Research Center
FISCAL YEAR 1987 ESTIMATES

Ames Research Center

Dryden Flight Research Facility

FISCAL YEAR 1987 ESTIMATES



RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987 ESTIMATE

LANGLEY RESEARCH CENTER

DESCRIPTION

The Langley Research Center (LaRC), located at Hampton, Virginia, was established in 1917. It is situated between Norfolk and Williamsburg, Virginia, in the Tidewater area of Hampton Roads. The Center utilizes 807 acres of Government-owned land, divided into two areas by the runway facilities of Langley Air Force Base. Runways, some utilities, and certain other facilities are used jointly by NASA and the Air Force. In addition, there are 110 acres of NASA-owned land located in the city of Newport News, Virginia, and 3,276 acres under permit from the Department of Interior. The total capital investment of the Langley Research Center, including fixed assets in progress and contractor-held facilities at various locations, as of September 30, 1985, was $765,250,000.

CENTER ROLES AND MISSIONS

Langley continues to play a leading role in the development of aeronautics and space technology. Technical excellence in specified research areas is attributed to the quality and capability of the civil service staff and to the availability of unique aeronautical facilities. The principal and supporting roles are:

PRINCIPAL

Transport Aircraft Technology - develop a technology base for improving transport aircraft as a cost effective, safe, and environmentally compatible transportation mode.

General Aviation and Commuter Aircraft Technology - develop and maintain an engineering technology base related to improving general aviation and commuter aircraft.

Transatmospheric Research and Technology - combine aeronautics and space disciplines to provide the technology for a future class of vehicles capable of flight to orbit and/or hypersonic cruise.

High-Speed, Highly Maneuverable Aircraft Technology - conduct cutting edge discipline research applicable to military aircraft and missiles.

Fundamental Aerodynamics - advance the general state-of-the-art, both theoretical and experimental.

Acoustics and Noise Reduction - conduct research and develop a technology base related to reducing interior and exterior aircraft noise.

Aerospace Vehicle Structures and Materials - develop a technology base for potential advances.

Guidance and Control Technology - develop a technology base related to improving aircraft and spacecraft control and guidance systems.

Advanced Space Vehicle Configuration Technology - develop technology for advanced vehicle transportation systems, including orbit-on-demand vehicles, aeroassisted orbit transfer, transatmospheric vehicles, and maneuvering reentry vehicles.

Advanced Space Systems Technology - develop a technology base and systems analysis capability for large space antenna applications and space station system trade studies.

Sensor and Data Acquisition Technology - develop a technology base for sensors and data acquisition devices.

Technology Experiments in Space - define and develop space technology experiments in support of LaRC roles including materials, structures, control and dynamics of large space structures, large space antenna systems, remote sensoring atmospheric sciences, and advanced transportation systems.

Atmospheric Sciences Technology - develop improved techniques for atmospheric sensing. Includes research, experiment development/management, data analysis, and investigator management and specialized ground/aircraft investigations. This also includes development of Shuttle payloads related to atmospheric sensing.

Upper Atmospheric Research - provide mission analysis, sensor development, data interpretation, and utilization for remote sensing; contributing to model development.

Hypersonic Propulsion Systems - contribute to the technology base of airbreathing propulsion systems by advancing the state-of-the-art of hypersonic propulsion.

SUPPORTING

Rotorcraft Technology - contribute to the development of the technology base with emphasis on structures, aeroelasticity, acoustics, noise, and avionics components.

Planetary Entry Technology - provide planetary and entry aerothermodynamics experimental and analytical data.

Computational Fluid Dynamics - contribute to the software technology base.

Launch Vehicle Procurement - develop and procure for science/applications missions, including Scout launch vehicle.

SUMMARY OF RESOURCES REQUIREMENTS

Funding Plan by Function

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	116,525	119,762	117,556	118,595
II. Travel	2,735	3,175	2,935	3,220
III. Operation of Installation	27,862	31,279	29,538	33,218
A. Facilities Services	(15,968)	(18,092)	(17,112)	(18,057)
B. Technical Services	(3,304)	(5,197)	(4,436)	(6,771)
C. Management and Operations	(8,590)	(7,990)	(7,990)	(8,390)
Total, Fund Requirements	147,122	154,216	150,029	155,033

Distribution of Civil Service Workyears

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
RESEARCH AND DEVELOPMENT	2,070	2,144	2,145	2,147
Space Station	66	50	55	55
Space Transportation Capability Development	15	10	2	2
Space Science and Applications	232	188	187	192
Physics and Astronomy	7	---	6	1
Life Sciences	7	6	6	6
Space Applications	218	182	175	185
Commercial Programs	10	12	10	9
Technology Utilization	9	8	8	7
Commercial Use of Space	1	4	2	2
Aeronautics and Space Technology	1,748	1,884	1,892	1,890
Aeronautical Research and Technology	1,304	1,355	1,375	1,332
Transatmosperhic Research and Technology	---	---	---	70
Space Research and Technology	443	529	516	487
Space Flight, Control and Data Communications	38	25	24	22
Shuttle Production and Operations Capability	11	---	---	---
Space Transportation Operations	27	25	24	22
Subtotal, direct workyears	2,108	2,169	2,169	2,169
Center Management Operations Support	716	639	643	643
Total, full-time workyears	2,824	2,808	2,812	2,812
Other than full-time	109	97	99	99
Total, workyears	2,933	2,905	2,911	2,911

PROGRAM DESCRIPTION

Permanent Civil
Service Workyears

RESEARCH AND DEVELOPMENT

SPACE STATION.. 55

Space Station effort will consist of direct support to systems engineering activities, user accommodation and utilization efforts, and advanced technology development work. Additionally, LaRC will perform definition and integration studies and will define and analyze evolutionary options.

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT....................................... 2

The objective of this activity is to evaluate alternate crew safety strategies for near- and far-term space mission scenarios; to establish safety criteria and identify technology requirements to meet those criteria; and to perform design synthesization, analytical modeling, and systems analysis and evaluation tasks on competing space station technology concepts.

PHYSICS AND ASTRONOMY.. 1

The objective of the Heavy Nuclei Collection Project is to obtain data on heavy nuclei in space for use in studies of the nucleo synthesis in recent explosive processes in the Universe and for use in the fundamental nuclear physics and astrophysics studies.

LIFE SCIENCES... 6

This research brings together an interdisciplinary program to investigate hypotheses concerning the role of wetland ecosystems in the global methane cycle and the concentration and flux of organic carbon. The radiation effects and protection program focuses on shielding and radiation physics through fundamental study of the interactions with and transport through materials of radiation, including galactic and solar cosmic rays and trapped radiation.

SPACE APPLICATIONS.. 185

The space applications program at Langley provides a national research capability for understanding the environment and for developing related atmospheric sensing systems and techniques. The Center's technical expertise is widely recognized in the areas of remote sensing of the Earth's atmospheric trace species and of theoretical and empirical atmospheric modeling. In the area of Upper Atmospheric Research, Langley civil service personnel will continue to study the Earth's atmosphere in 1987 to assess any changes caused by man and determine whether or not there is any associated change in the chemical composition of the stratosphere that would change the transmission of solar ultra violet to the Earth's surface. Efforts will continue in defining and developing Shuttle and satellite experiments which will provide measurements of atmospheric constituents and other characteristics.

A significant improvement in the understanding of man's impact on the atmosphere and climate will be obtained from the combination of Langley developed statistical/theoretical models and the comprehensive global data set provided by spaceborne sensors such as Limb Infrared Monitor of the Stratosphere, Stratospheric Aerosol Measurements II, Stratospheric Aerosol and Gas Experiments, Measurement of Air Pollution from Satellites, and Earth Radiation Budget Experiments. The Center's sensor development program encompasses the broadest possible range of advanced remote sensing techniques, including correlation gas filter radiometry and interferometry, laser heterodyne radiometry, lidar, and active and passive microwave techniques.

The Center is managing the Global Tropospheric Experiment which is a coordinated program of theoretical modeling, field measurements, data analysis, and technology development to contribute to the enhanced understanding of the chemical and dynamic processes of the global troposphere.

Studies of the Earth's radiation budget are fundamental to the understanding of climate phenomena. Langley has the responsibility for the sensor development, and data management for the Earth Radiation Budget Experiment, a prime element in NASA's support of the National Climate Program. Preliminary radiation budget studies, based on Nimbus data, are examining the relationship of radiation budget to such climatological parameters as cloudiness, snow and ice cover, and sea surface temperature. The Earth Radiation Budget Experiment satellite, equipped with the instruments which were the responsibility of Langley Research Center, was launched in October 1984; the instruments on NOAA 9 were launched in December 1984; and the last set of instruments is scheduled for launch in Spring 1986 on NOAA G; thus analysis of the data will be continued in 1987.

	Permanent Civil Service Workyears
TECHNOLOGY UTILIZATION..	7

The general objective of the NASA technology utilization program is to enhance economic growth and contribute to the technological solution of public problems through the transfer of new technology, from aeronautical and space research and development efforts, to the nonaerospace segments of the economy.

In 1987, civil service personnel will provide support to define methods to expedite the application of new technology through the compression of the time required from generation of technology to its use in the economy; and encourage the use of aerospace technology in nonaerospace segments of the economy having problems amenable to technological solutions.

Permanent Civil
Service Workyears

COMMERCIAL USE OF SPACE... 2

The objective of the Commercial Use of Space program is to increase private sector awareness of space opportunities and encourage industry investment and participation in high technology space based research and development. This effort will establish an organizational focal point to initiate a program specifically intended to foster commercial use and access to space.

AERONAUTICAL RESEARCH AND TECHNOLOGY... 1,332

The aeronautical and research technology program at Langley is characterized by the dynamic interaction between a broad spectrum of technical disciplines, the application of discipline research to specific technology requirements, demonstrations of particular technology applications, and the in-depth examination of future technology requirements. The unique wind tunnel, computing facilities, and flight operations capability at Langley complement the expertise of the technical staff to produce a broad cohesive program in aeronautical research.

The aerodynamics activity at Langley encompasses extensive theoretical and experimental activities. Basic work in fluid and flight mechanics involves theoretical and experimental determination of aerodynamic flows and complex aircraft motions. The program utilizes the unique Langley capabilities made possible by the VPS-32 computer and recently-developed cryogenic wind tunnel testing capability provided in the national transonic facility which allows the full simulation of flight conditions.

Research areas include airfoil and wing design, flow-field analysis, configuration design processes, aircraft noise prediction, control analysis, aircraft drag reduction, propulsion system integration, flight dynamics, and fighter and missile aerodynamics. The VPS-32 computer will be used in the areas of far-field noise, three-dimensional (3-D) potential flow programs, and the solution of 2-D and 3-D Navier-Stokes equations. Wind tunnel and flight tests will be continued on general aviation aircraft configurations having the potential for practical stall immunity and means for spin avoidance. Basic research on the conception and development of methods for reducing turbulent skin-friction drag and the designs for both passive and active laminar flow airfoils will be pursued. A goal of the activities in the viscous drag reduction area is to validate the various concepts to the level required for aircraft manufacturers to consider their use in future production aircraft. Application of advanced transonic theories to the design of improved 3-D wings will be continued and evaluated by wind tunnel tests. The development of design methodology for high-performance aircraft at high angles-of-attack in the areas of aerodynamics, controls, and handling qualities will be accelerated. Technology options for realization of practical hypersonic and transatmospheric flight are being studied.

Activities in acoustics and noise reduction include research on jet noise, propeller noise, interior noise, rotor blade noise, atmospheric propagation, structure-borne noise, and system noise prediction.

The materials and structures effort is directed at the development of new and improved structural materials, manufacturing processes, and design technology to improve the structural efficiency, reliability, and durability and to reduce design costs of airframes and components. This activity is directed toward research on advanced composite materials, advanced metallic materials, computer aided analysis and design technology, and development of analytical or semiempirical fatigue and life prediction methodology. Use of active and passive controls for minimization of aeroelastic response, reduced static stability, and minimization of gust and maneuver loads is being pursued in both theoretical and wind tunnel studies.

Emerging technological advances in computer systems are being exploited to significantly increase the utility and reduce the cost of engineering computations. The Langley research program in computer science is directed at software systems for distributed computer networks, methods for concurrent systems design, software engineering, fault tolerant software techniques for improved system reliability, and software development management. Investigations of advanced computer hardware applications will be continued with analysis of finite element structural computational costs.

Controls and guidance work at Langley includes research programs to advance technology development in aircraft guidance and navigation, aircraft control systems, cockpit systems and integration and interfacing techniques, and performance validation and verification methods for fully integrated, highly reliable flight control systems. Also, major efforts in aircraft flight management and operating procedures technology and active controls technology for conventional takeoff and landing aircraft are being conducted in this program area. The work includes requirement analyses, design studies, ground simulations, and experimental flight research. The Langley expertise in the controls and guidance area is being applied to various aircraft classes, intersystems communications networks for enhanced interfacing and integration of functions within an aircraft, flight path definitions, and advanced technology for pilot/system interfaces for both aircraft and spacecraft. Investigations will continue on the integration of aircraft with enhanced capabilities and the evolving air traffic control system to achieve benefits in capacity and efficiency while maintaining safety. Other efforts will include the definition of technology for enhanced functional integration to increase aircraft systems reliability and reduce operating cost, and the investigation of concepts and technology which will result in greatly improved aircraft displays and input/output capabilities. Other technology applications are found in research on advanced flight control systems, design procedures, handling and flying qualities criteria for advanced aircraft, and pilot modeling and assessment of pilot performance and workload. Research efforts in developing and applying artificial intelligence technology to aircraft cockpits will be undertaken. The avionics integration research laboratory continues to be used for both NASA and industry research on fault tolerant systems. The impact of lightning on inducing errors in digital aircraft systems will continue to be assessed.

Langley has traditionally received requests from other agencies and industry for test support of their aircraft, missiles, and systems development programs. The Aerostructures Directorate of the U.S. Army Aviation Research and Technology Activity, and the Aviation Technology Directorate, both under Aviation Systems Command (AVSCOM) are located at Langley. These directorates, the primary investigators of Army rotorcraft structures and avionics, work on independent research and development projects and on projects of mutual interest with a staff integrated into the NASA organization. Extensive use is made of Langley facilities in these research activities. There are also a large number of joint programs with the Air Force Systems Command, the Naval Air Systems Command, other DOD components, and the Federal Aviation Administration.

Permanent Civil
Service Workyears

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY.. 70

The Transatmospheric Research and Technology activities at Langley include: development of fundamental processes and engineering feasibility of supersonic combustion of both ramjets and other advanced airbreathing propulsion systems; characterization of advanced materials for high temperature applications and the development of large hot reusable structures for aerospace vehicles; efforts in high-speed aerodynamics, configurations and advanced computational methods for a variety of vehicle applications; and the conduct of studies to define and understand the integration of advanced technologies into a future class of horizontal take-off and landing vehicles for operation to orbit and/or hypersonic cruise within the atmosphere.

SPACE RESEARCH AND TECHNOLOGY.. 487

The space research and technology program at Langley is characterized by levels of effort in several discipline areas and the application of expertise to current and future technology requirements. Longer range studies are directed at defining the technology requirements for future space systems and missions technology development for a permanently manned space station.

The objective in the materials area is to establish and demonstrate the required technology for application of advanced materials for a wide variety of space applications. Materials systems and applications include: high-temperature composites with long-life capability for use as structural materials in future space transportation systems; high-temperature metallic materials for thermal protection systems; and high-stiffness, low-weight, low-thermal expansion composites for large, long-life space structures.

Environmental effects on the mechanical and physical properties of materials are being studied utilizing specialized facilities and laboratories. These studies include dimensional stability and radiation stability of composites and thermal control coating. An integral part of the research activity is the definition of new experimental testing and research facility requirements which will assure that the reliability and durability of future space structures can be adequately predicted and assessed.

The goal of the activities in the area of structures is to provide validated analysis and design methodology, design concepts, and dynamics and control methodology required for efficient long-life space transportation and payload structures. High-temperature metallic heat shield concepts and actively cooled structural and propulsion concepts for advanced space transportation systems are being derived and evaluated using specialized laboratories and wind tunnels. Analysis, design, and loads determination methodology for deployable and erectable large space platforms, antennas, and booms are being studied as part of a multi-center, multi-disciplinary program for advanced technology. A technology program is being developed to demonstrate and validate the control of large flexible space structures through analysis and flight testing. An integrated structural-thermal analysis methodology is being developed and verified for spacecraft structures. Work will be initiated on integral controls software that will require application of advanced numerical techniques and computer hardware.

An extensive program in electronic component technology, automation/robotics technology, and information systems technology is conducted at Langley. Sensor research includes continuously tunable infrared laser techniques, and high-power/high-pressure tunable gas lasers for the measurement of low concentration atmospheric constituents and transport phenomena (e.g., winds). Research will continue on the extension of microwave radiometer technology to large space systems. Onboard data management system concept will be carried out in 1987. This work supports a broad objective of developing candidate architectures and associated systems technology for manned spacecraft onboard data management, with potential application to the space station. The demonstration of a wavelength division multiplexed fiber optic technology is underway at Langley. The objective of this research is to provide the component technology base for advanced local area networks used in the space station or other complex aerospace systems. The unique micro-G environment of space provides an opportunity to develop advanced materials processing concepts. Langley is investigating the potential of diffusion limited crystal growth as a technique to provide large uniform lead tin telluride crystals with potential application in infrared sensors. The evaluation of solid-state data storage technology for space station applications has been initiated. The overall objective is to identify candidate technologies, evaluate their potential, and perform research necessary to demonstrate viability in projected space station environment. Langley is evaluating advanced optical data processing techniques which take advantage of the parallelism of optics to perform complex mathematical operations such as matrix arithmetic at high speed for potential application to complex aerospace systems. Automation technology efforts will focus on conducting systems level research on remote satellite servicing concepts and application of artificial intelligence technology. Other space electronics technology efforts are focused on spacecraft attitude control, software development, verification and validation techniques, and special problems in large space structures pointing and figure control.

The objective of the Langley space vehicle and spacecraft technology program is to develop experimental and theoretical data bases to support: development of space transportation system (STS) vehicles for the 1990's and beyond, employing technologies advanced beyond those utilized for the space shuttle; the evolving STS program and solve operational problems as they surface; and reduction and interpretation of STS flight data. The objectives are being met through the development and application of experimental and theoretical techniques employing LaRC computers and wind tunnel facilities and through comparative analyses of the resulting data with flight data as available. Disciplines include aerodynamic/thermodynamic performance, configuration optimization, flight control system assessment, mission design, planetary entry trajectory analyses, and computational flow field techniques.

The space shuttle orbiter will be utilized as a research vehicle to extend the knowledge of aerodynamics, aerothermodynamics, and basic fluid mechanics into previously inaccessible flow regimes by acquiring flight measurements during routine shuttle operations. Experiments have been developed for space shuttle flights which will provide unique measurements for direct assessment of ground-based facility measurements and theoretical techniques. The space shuttle will also be utilized as a space platform from which to perform Langley-developed payload experiments extending basic research and technology development into the space environment when economically feasible or when the development can be achieved in space.

The Langley program in space energy conversion is focused on radiant energy conversion concepts which convert solar and laser radiation efficiently into electricity or other useful forms of energy. The objective of the energy conversion effort is to perform basic research on solar-pumped lasers for conversion of solar energy directly into electromagnetic radiation, laser power or work for potential power generation, transmission, storage, and control for future space missions.

Permanent Civil
Service Workyears

SPACE TRANSPORTATION OPERATIONS 22

The expendable launch vehicle program at Langley provides centralized procurement of the Scout launch vehicle. In 1987, civil service personnel will support a program which includes the procurement of launch vehicle hardware, launch services, engineering, and maintenance. Launches under this program will be conducted from sites located at the Western Space and Missile Center in California, Wallops Flight Facility in Virginia, and San Marco Equatorial Range, Kenya, Africa.

CENTER MANAGEMENT AND OPERATIONS SUPPORT.. 643

Center management and operations support provides services or support to all Langley organizations which cannot be identified exclusively to a single program or project. The civil service personnel involved are:

Director and Staff - The Center Director, Deputy Director, and immediate staff; e.g., Chief Scientist, Equal Opportunity, and Public Affairs.

Management Support - Provide information and control services supporting all levels of Center management, both program and functional. Specific functions include resources and financial management, program control, contracting and procurement, property management, personnel management, and management systems and analysis.

Operations Support - Provide for the operation and maintenance of institutional facilities, buildings, systems, and equipment, including those who manage or provide technical services such as automatic data processing, reliability and quality assurance, medical care, and photographic support.

RESOURCES REQUIREMENTS BY FUNCTION

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
I. PERSONNEL AND RELATED COSTS	116,525	119,762	117,556	118,595
Summary of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Full-time permanent	100,033	104,061	101,036	101,826
b. Other than full-time permanent	1,795	1,693	1,725	1,725
c. Overtime and other compensation	1,158	987	1,283	1,283
Subtotal, Compensation	102,986	106,741	104,044	104,834
2. Benefits	12,549	12,225	12,372	12,491
Subtotal, Compensation and Benefits	115,535	118,966	116,416	117,325
B. Supporting Costs				
1. Transfer of Personnel	159	86	180	180
2. Personnel Training	831	710	960	1,090
Subtotal, Supporting Costs	990	796	1,140	1,270
Total, Personnel and Related Costs	116,525	119,762	117,556	118,595

Explanation of Fund Requirements

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
A. Compensation and Benefits	115,535	118,966	116,416	117,325
1. Compensation	102,986	106,741	104,044	104,834
a. Full-time permanent	100,033	104,061	101,036	101,826

The decrease from the 1986 budget estimate to the 1986 current estimate reflects the current distribution between permanent and other FTEs.

Basis of Cost for Civil Service Workyears

In FY 1987, the cost of permanent workyears will be $101,826,000. The increase results from the following:

Cost of full-time permanent workyears in 1986		101,036
Cost increases in 1987		2,179
Within grade and career development advances:		
Full year effect of 1986 actions	957	
Partial year effect of 1987 actions	1,222	
Cost decreases in 1987		-1,389
Turnover savings:		
Full year effect of 1986 actions	-363	
Partial year effect of 1987 actions	-1,026	
Cost of full-time permanent workyears in 1987		101,826

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of	Dollars)	
b. Other than full-time permanent				
1. Cost	1,795	1,693	1,725	1,725
2. Workyears	135	131	133	133

The distribution of 1987 workyears is as follows:

Distribution of Other Than Full-Time Permanent Workyears

Program	Workyears
Developmental programs	85
Youth Opportunity programs	34
Other temporary	14
Total	133

The increase in the 1986 current estimate reflects the level in the developmental programs and other temporaries.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
c. Overtime and other compensation	1,158	987	1,283	1,283

The major cost in this area is overtime. Also included are holiday pay, incentive awards, and bonus awards. The use of overtime and other compensation is limited to emergency repairs and work that cannot be accomplished during normal duty hours. This includes the monitoring of on-site contracts being performed during off-duty hours and wind tunnel work required at night to take advantage of off-peak electrical rates. The increase from the 1986 budget estimate to the 1986 current estimate and continuing into 1987 reflects additional running of wind tunnels to compensate for accidents in the 16-foot and 7- by 10-foot tunnels.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Benefits	12,549	12,225	12,372	12,491

The following are the amounts of contribution by category:

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Civil Service Retirement Fund	7,063	6,856	7,156	7,228
Employee life insurance	249	266	252	255
Employee health insurance	3,000	2,967	3,013	3,044
Workmen's compensation	919	919	609	609
FICA	105	23	107	108
Medicare	1,209	1,174	1,220	1,232
Other Benefits	4	20	15	15
Total	12,549	12,225	12,372	12,491

The increase from the 1986 budget estimate to the 1986 current estimate is due to increase in civil service retirement, health insurance, and FICA offset by workmen's compensation. The 1987 estimate reflects the change in compensation estimates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Supporting Cost	990	796	1,140	1,270
1. Transfer of personnel	159	86	180	180

Transfer of personnel includes actual expenses involved in the movement and temporary storage of an employee's household goods, subsistence and temporary expenses, real estate costs, and miscellaneous moving expenses. The increase from the 1986 budget estimate to the 1986 current estimate reflects a change in the GSA policy regarding payment for PCS moves and household goods.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Personnel training	831	710	960	1,090

The purpose of the training program is to continue the development and education of civil service employees to support Langley's roles and missions more efficiently. The 1986 current estimate and the 1987 budget estimate reflects increased training requirements for those responsible for developing, designing, implementing, and validating programs for large mainframe computers, office automation and the new Space Station initiative.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
II. TRAVEL	2,735	3,175	2,935	3,220

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	1,881	2,392	2,163	2,417
B. Scientific and Technical Development Travel	608	583	583	607
C. Management and Operations Travel	246	200	189	196
Total, Travel	2,735	3,175	2,935	3,220

Explanation of Fund Requirements

A. Program Travel	1,881	2,392	2,163	2,417

Program travel is directly related to the accomplishment of the Center's mission. Travel for program purposes reflects the continuing effort in space research, aircraft technology, flight simulation, fluid mechanics, airborne science and applications, space applications, Space Station, and Shuttle support. The decrease from the 1986 budget estimate to the 1986 current estimate reflects a realignment of program requirements. The 1987 estimate reflects essentially the same level of travel as 1986 but reflects anticipated air fare rate increases.

B. Scientific and Technical Development Travel	608	583	583	607

Scientific and technical development travel permits employees to participate in meetings and technical seminars with other representatives of the aerospace community. Participation allows staff to benefit from exposure to technological advances outside Langley, as well as to present both accomplishments and problems to their associates. Many of the meetings are working panels convened to solve certain problems for the benefit of the Government. The 1987 estimate reflects anticipated price levels.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
C. Management and Operations Travel......................	246	200	189	196

Management and operations travel is used for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, and procurement activities; travel of the Center's top management to NASA Headquarters and other NASA Centers; peer group reviews; and local transportation. The decrease in the 1986 current estimate from the 1986 budget estimate reflects a constraint on travel in order to support programmatic requirements. The 1987 estimate reflects the same level of travel as in 1986.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
III. OPERATION OF INSTALLATION	27,862	31,279	29,538	33,218

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Facilities Services	15,968	18,092	17,112	18,057
B. Technical Services	3,304	5,197	4,436	6,771
C. Management and Operations	8,590	7,990	7,990	8,390
Total, Operation of Installation	27,862	31,279	29,538	33,218

Explanation of Fund Requirements

Operation of Installation provides a broad range of services, supplies, and equipment in support of the Center's institutional activities. These are divided into three major functional areas: Facilities Services, the cost of maintaining and operating institutional facilities and equipment, and the cost of custodialservices and utilities; Technical Services, the cost of automatic data processing for management activities, and the cost of educational and informational programs and exhibits; and Management and Operations, the cost of administrative communications, reproduction, transportation, medical, and logistic services.

The decrease from the 1986 current estimate to the 1986 budget estimate is the result of reduced operational maintenance support, lower than anticipated utility rates and a rephasing of contractor obligation plans. The 1987 budget estimate provides for projected increases in support contractor rates, supplies, materials, equipment, and utility rates, and a full year funding of support service contracts.

A. FACILITIES SERVICES	15,968	18,092	17,112	18,057

The Langley complex encompasses 2,068,679 gross square feet of building and space. Included are 19 major technical facilities. This physical plant houses an average daily on-Center population of 4,100 to 4,400 personnel. Many of the test facilities are utilized on more than one shift or during off-peak hours.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Rental of Real Property......................	---	7	7	7
2. Maintenance and Related Services............	494	1,126	506	562
3. Custodial Services..........................	3,918	3,429	3,349	3,563
4. Utility Services............................	11,556	13,530	13,250	13,925
Total, Facilities Services.................	15,968	18,092	17,112	18,057

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Rental of Real Property......................	---	7	7	7

The estimates shown here are the costs of leasing rights of way for access to model drop zone areas at Plum Tree Island.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Maintenance and Related Services............	494	1,126	506	562

This estimate provides funds for maintenance and repair of administrative facilities, roads and utility lines, and grounds maintenance. The decrease from the 1986 budget estimate to the 1986 current estimate reflects delay and deferral of activities and a rephasing of support contractor funding plans. The increase in 1987 is due to anticipated support contractor wage increases and the full year funding of support contracts.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
3. Custodial Services..........................	3,918	3,429	3,349	3,563

This activity provides for janitorial and security services. Also included are funds for fire protection services provided by the City of Hampton. The decrease from the 1986 budget estimate to the 1986 current estimate reflects a slight cost decrease in janitorial, security, and fire protection services. The 1987 estimate provides for the same level of effort at anticipated rate increases.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
4. Utility Services	11,556	13,530	13,250	13,925

Included in this item is the purchase of electric service from Virginia Power Company, fuel oil from a local supplier, and water and sewage charges. Also included are funds for heat and steam services from the Air Force for East Area facilities and the purchase of steam from Hampton for facilities located in the West Area of Langley and for operation of the City of Hampton, Air Force and NASA Cooperative Refuse Burner. The decrease from the 1986 budget estimate to the 1986 current estimate reflect less than anticipated increases in the cost of electricity coupled with a slight increase in Refuse Burner costs. The 1987 budget estimate reflects anticipated rate increases.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. TECHNICAL SERVICES	3,304	5,197	4,436	6,771

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing	2,267	4,013	3,463	5,910
a. Equipment	969	715	763	1,792
b. Operations	1,298	3,298	2,700	4,118
2. Scientific and Technical Information	1,037	1,184	973	861
a. Library	250	261	260	275
b. Education and Information	787	923	713	586
Total, Technical Services	3,304	5,197	4,436	6,771

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing	2,267	4,013	3,463	5,910

Funds for the Center's business computer complex which provides the accounting and management information data are provided in this function. Included are equipment lease, purchase and maintenance; paper and other expendable supplies; a contract for programming and operations; and several small contracts. The decrease from the 1986 budget estimate to the 1986 current estimate is due to deferral of equipment purchases and a rephasing of support contractor funding plans. The 1987 estimate provides for expected support contractor rate increases, the full year funding of support contracts and a critically needed upgrade of the administrative computer central processing unit.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Scientific and Technical Information..............	1,037	1,184	973	861

This estimate provides support contractor assistance in the operation of the Technical Library and Visitor Information Center. Funding for all the Center's public affairs activities is included in these estimates. Also included is support for operation of the Visitor Information Center, coordination of tours and special events, construction and transportation of exhibits, and other miscellaneous educational and informational programs. The decrease in the 1986 current estimate and the 1987 budget estimate reflects deferral of the Visitor Center exhibit construction and reduced support for exhibits maintenance.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
C. MANAGEMENT AND OPERATIONS............................	8,590	7,990	7,990	8,390

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications.....................	2,525	2,441	2,441	2,566
2. Printing and Reproduction........................	151	157	158	159
3. Transportation..................................	2,201	2,262	2,008	2,244
4. Installation Common Services.....................	3,713	3,130	3,383	3,421
Total, Management and Operations................	8,590	7,990	7,990	8,390

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications....................	2,525	2,441	2,441	2,566

Includes funds for local telephone and exchange costs; Federal Telecommunications Systems (FTS) services; and datafax and telegraph service. The budget estimate for 1987 reflects the same level of service as 1985 and 1986 at anticipated rate changes.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Printing and Reproduction........................	151	157	158	159

Provides supplies for reproduction services. The 1987 estimate reflects the same level of service as 1986.

3. Transportation...................................	2,201	2,262	2,008	2,244

Includes the operation, maintenance, and purchase of motor vehicles; shipping, transportation and freight charges. Also included are charges for local transportation, pickup and delivery of freight, furniture, and other bulk objects, and operation and maintenance of the administrative aircraft. This effort also includes all of the aircraft fuel, equipment, and expendable supplies. The decrease in the 1986 current estimate from the 1986 budget estimate defers replacement of motor vehicles. The 1987 estimate provides for continuation of the 1986 level at anticipated price levels.

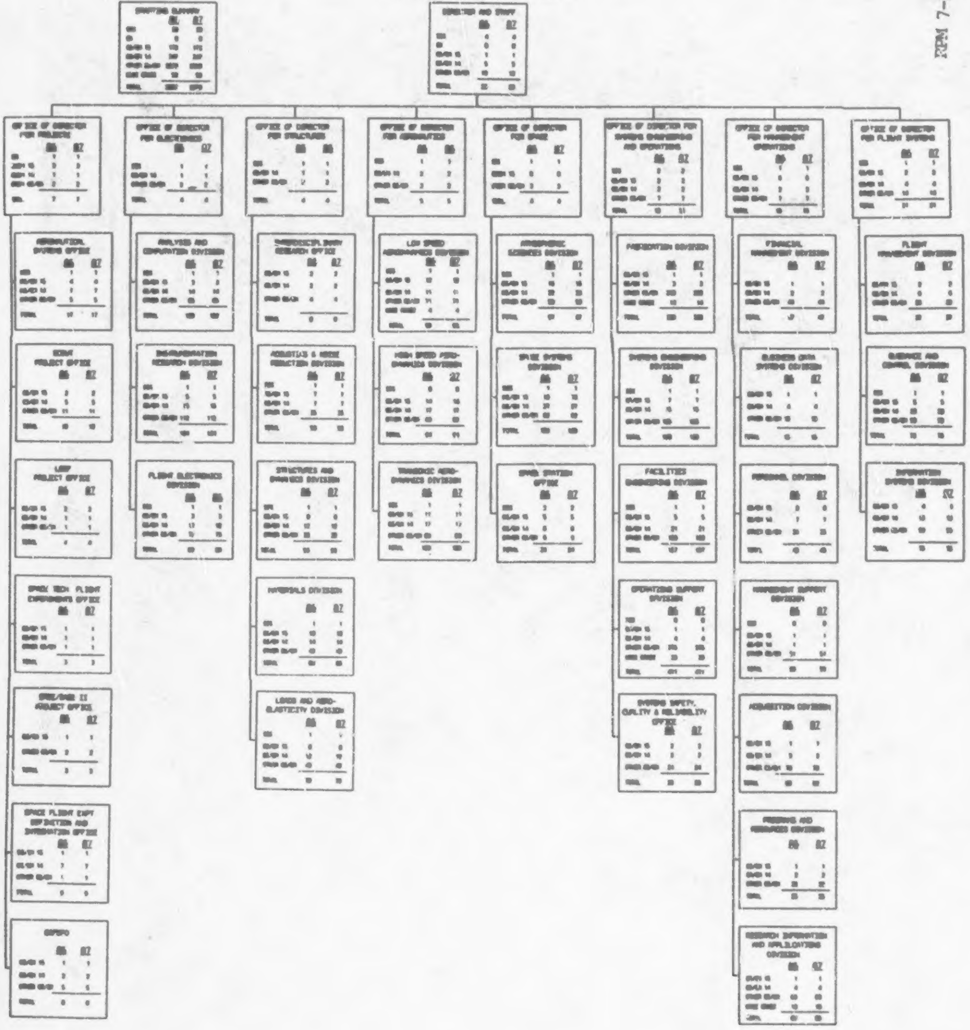
4. Installation Common Services......................	3,713	3,130	3,383	3,421

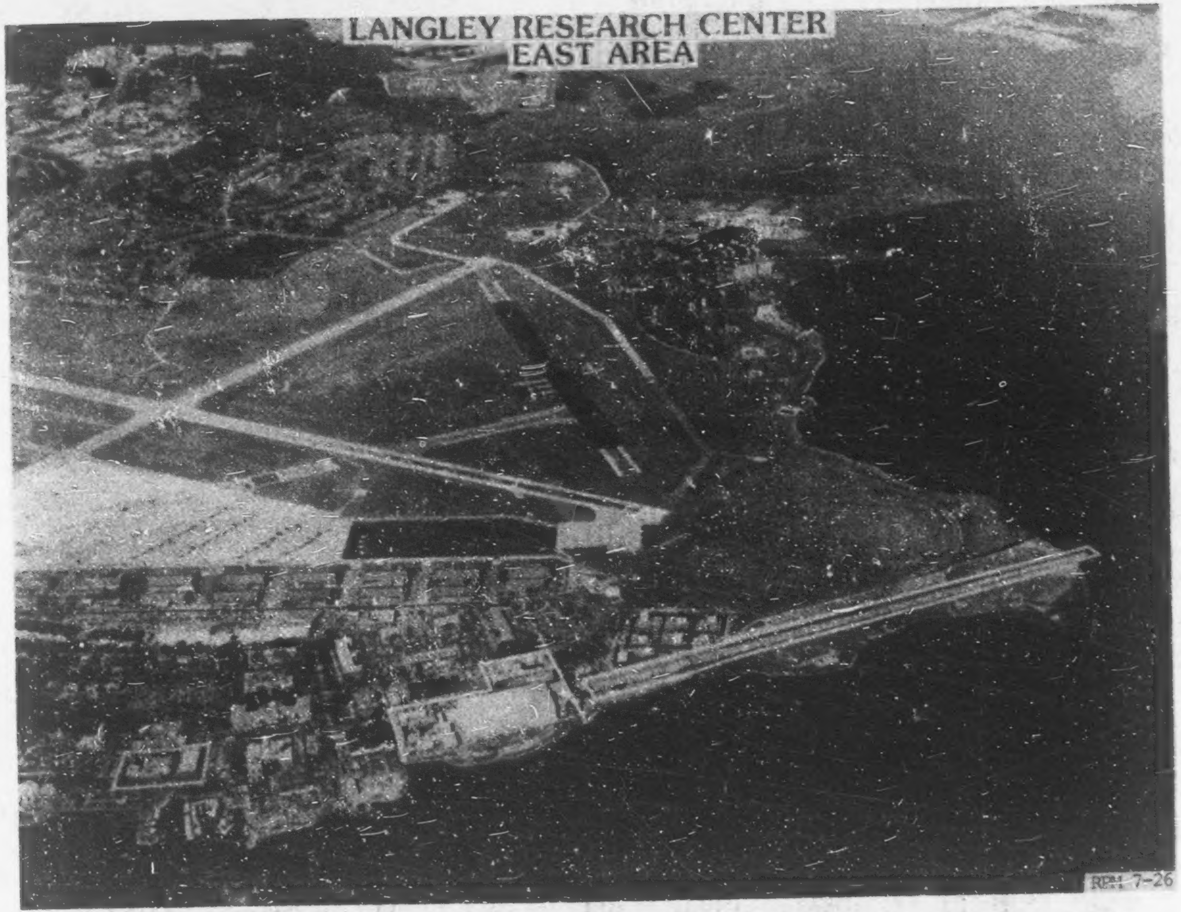
Provides for medical services, mail delivery, stock issue and warehousing, and other general administrative support. Also included are the rental and maintenance of office copy machines and equipment, minority programs, and other administrative services and supplies. The increase from the 1986 budget estimate to the 1986 current estimate reflects a reassessment of postage costs and employee assistance program. The 1987 estimate reflects the same level as 1986 adjusted for anticipated rate changes.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LANGLEY RESEARCH CENTER

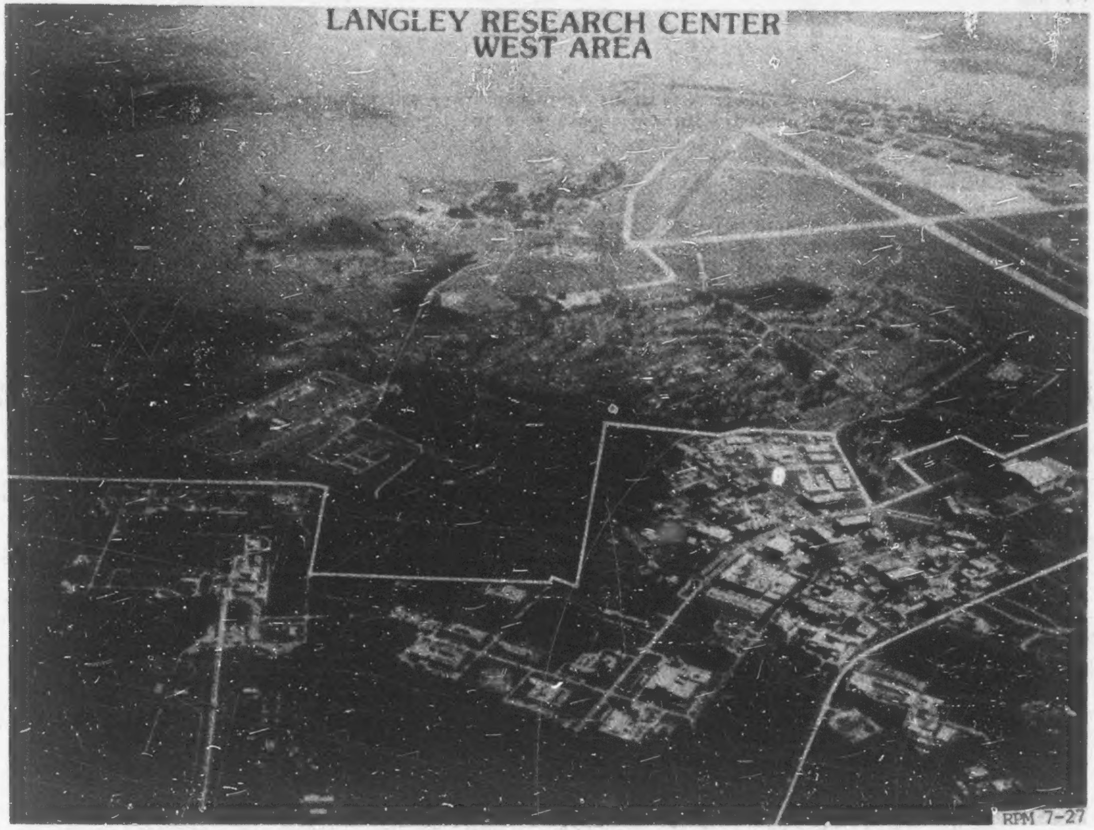
ORGANIZATION AND STAFFING CHART





LANGLEY RESEARCH CENTER
EAST AREA

RPM 7-26


LANGLEY RESEARCH CENTER
WEST AREA

RPM 7-27

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987 ESTIMATES

LEWIS RESEARCH CENTER

DESCRIPTION

The Lewis Research Center (LeRC) occupies two sites in north central Ohio. The original site, established in 1941, adjacent to the Cleveland-Hopkins International Airport, includes 366 acres, 14 of which are leased from the City of Cleveland. There are over 170 buildings and structures, including wind tunnels, test chambers, laboratories and other research facilities at the Cleveland location.

The Plum Brook Station, established in 1956, is located south of Sandusky, Ohio, about 50 miles west of Cleveland, on land formerly occupied by the Plum Brook Ordnance works. There are 6452 acres owned by NASA and approximately 47 acres in easements. During 1975, consistent with future NASA research and technology needs, the principal facilities were placed in a standby mode except the use of selected facilities by Federal, state and local government agencies or their contractors.

The total capital investment of Lewis and Plum Brook Station, including fixed assets in progress and contractor-held facilities at various locations, as of September 30, 1985, was $523,814,000.

CENTER ROLES AND MISSIONS

Lewis was established as an aircraft engine research laboratory to develop superior aircraft propulsion systems. Since then, Lewis has developed and constructed many unique facilities for testing full-scale aircraft engines and engine components, chemical rocket engines, electric propulsion systems, space and terrestrial power generation systems, and space communication systems. The principal and supporting roles are:

PRINCIPAL

Aeronautics - develop and maintain a preeminent national capability in: fundamental aeropropulsion disciplines including internal computational fluid dynamics, internal unsteady aerodynamics and aeroelasticity, hot section technology, aircraft icing phenomena; aeronautical propulsion and power transfer technologies including engine materials and structures, propulsion system integration, propellers, instrumentation and controls; and the associated research facilities and techniques.

Transatmospheric Research and Technology - combine aeronautics and space disciplines to provide the technology for a future class of vehicles capable of flight to orbit and/or hypersonic cruise.

Space Station - definition and development of the Space Station Power System.

Communications - develop the high-risk technology required to ensure continued U.S. preeminence in satellite communications and which will be applicable to a wide range of future communication system required by NASA, other government agencies and U.S. Industry.

Expendable Launch Vehicles - management and operation of the Atlas and Centaur launch vehicle systems for Government and commercial users.

Space Transportation System/High Energy Upper Stage - design, develop and manage the Shuttle Centaur Cryogenic Upper Stage for the Space Transportation System to support the launch of the Galileo, Ulysses, Venus Radar Mapper, and Air Force missions.

Space Propulsion Systems Technology - development and maintenance of the technology base for advanced primary and auxiliary space propulsion systems, including associated structures and materials technologies.

Space Energy Processes and Systems Technology - development and maintenance of the technology base for space power and energy conversion systems, including associated structures and materials.

In-Space Flight Experiments - develop and implement basic microgravity science experiments, especially in materials processing, and conduct flight experiments that contribute to technology developments for space power and propulsion systems.

SUPPORTING

Energy Processes and Systems Technology - management of research and technology projects for terrestrial energy generation and conservation systems.

SUMMARY OF RESOURCES REQUIREMENTS

Funding Plan by Function

		1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
			(Thousands of Dollars)		
I.	Personnel and Related Costs...........	110,068	112,741	111,482	112,842
II.	Travel................................	2,626	2,726	2,622	2,897
III.	Operation of Installation.............	24,689	29,318	28,873	34,581
	A. Facilities Services...............	(16,946)	(22,757)	(21,507)	(24,503)
	B. Technical Services................	(2,409)	(2,209)	(3,014)	(3,856)
	C. Management and Operations.........	(5,334)	(4,352)	(4,352)	(6,222)
	Total, fund requirements........	137,383	144,785	142,977	150,320

Distribution of Civil Service Workyears

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
RESEARCH AND DEVELOPMENT	2,023	2,001	2,068	2,078
Space Station	182	205	239	280
Space Transportation	164	130	156	143
Space Science and Applications	178	141	120	130
Space Applications	178	141	120	130
Commercial Programs	5	7	11	11
Technology Utilization	4	2	2	2
Commercial Use of Space	1	5	9	9
Aeronautics and Space Technology	1,494	1,518	1,542	1,514
Aeronautics	1,156	1,165	1,197	1,099
Transatmospheric Research and Technology	---	---	---	70
Space	338	353	345	345
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	76	54	60	50
Space Transportation Operations	76	54	60	50
Subtotal, Direct Workyears	2,099	2,055	2,128	2,128
CENTER MANGEMENT AND OPERATIONS	548	527	527	527
Total, full-time workyears	2,647	2,582	2,655	2,655
Other than full-time workyears	77	110	39	39
Total, workyears	2,724	2,692	2,694	2,694

PROGRAM DESCRIPTION

RESEARCH AND DEVELOPMENT

	Permanent Civil Service Workyears
SPACE STATION	280

Space Station effort consists of power system definition studies, advanced technology development and initial development efforts. Lewis manages an agency-wide advanced technology development program to define and develop power system technology options and also conducts a portion of the propulsion advanced development effort in support of the Marshall Space Flight Center.

SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	143

Design, development, production and operation of the Centaur G. and Centaur G-Prime cryogenic upper stages are managed by the Shuttle/Centaur Project Office at Lewis. In 1987, civil service personnel will continue to support the activities associated with fabrication and qualification of the Centaur G vehicles. Significant efforts will also include integration of the Centaur G into the Space Transportation System's Kennedy Space Center operation for the 1988 Venus Radar Mapper mission and various DOD missions. The first two Centaur G vehicles will be delivered to Kennedy Space Center in 1986.

SPACE APPLICATIONS	130

The Space Applications activity at Lewis consists principally of space communications research. In 1986 Civil Service personnel will continue to support studies of various advanced satellite communications systems concepts directed at providing additional frequency bands and improved communications service. These studies are being focused on the needs of the public and private sectors, both nationally and internationally. Lewis will continue to develop technology with possible application to both ground and space segments of future advanced civil and military communications systems.

In 1987, Lewis will increase it's work in advanced design and development of scientific flight experiments in basic science and technology associated with materials combustion and fluid dynamics phenomenon in reduced gravity.

TECHNOLOGY UTILIZATION	2

The 1987 technology utilization program at Lewis will continue to concentrate on the identification and evaluation of technology which can be transferred to the non-aerospace industry, and on active programs to communicate and transfer the technology.

Permanent Civil
Service Workyears

COMMERCIAL USE OF SPACE... 9

The Commercial Use of Space program at Lewis will continue to assist industry in evaluating the commercial potential of space by providing the Lewis Research Center's ground-based facilities and microgravity aircraft, and technical expertise for evaluation and testing of ideas/concepts. Specific areas of microgravity research being pursued include processing of metals and alloys, glasses and ceramics, polymers, biological materials and semiconductor materials. Target industries are being identified and approached to determine whether the space environment can be utilized for profit-making purposes.

AERONAUTICAL RESERACH AND TECHNOLOGY................................. 1,099

Lewis' major research and technology responsibility in aeronautics is propulsion. The primary goal is to establish aeropropulsion technology which contributes significantly to the continuing preeminence of the U.S. civil and military aircraft industry. The approach is to provide the technology base for developing advanced aeronautical propulsion systems which will lead to improvements in fuel efficiency, operating cost, reliability and durability, and which will operate with acceptable environmental impact. The Lewis aeropropulsion program includes key generic discipline research, focused interdisciplinary research, and efforts focused on specific propulsion systems/vehicle applications. The Propulsion Directorate of the U.S. Army Aviation Research and Technology Activity under the Aviation Systems Command is co-located with NASA Lewis and jointly conducts independent research and technology development projects and other activities of mutual interest.

The generic discipline research includes internal computational fluid mechanics (ICFM), materials, and computational structural mechanics. The objective of this research is to develop an understanding of the physical phenomena involved in these disciplines so that accurate analytical tools can be developed to predict and to improve propulsion system performance. The scope of the ICFM research includes computational methods, modeling and verification, and applications. The advanced materials research is focused on superalloys, intermetallics, coatings, ceramics and composites for high temperature propulsion system applications. Computational structural mechanics involves the development and verification of advanced analytical methods for structural dynamics, fracture mechanics, and the development of life prediction methodology.

The focused interdisciplinary propulsion research includes icing, instrumentation and control technology, and hot section technology. Icing research brings together disciplines such as fluid mechanics and heat transfer to improve the analytical tools required for predicting icing effects, and to develop advanced ice protection systems. The goal of the icing research is to develop the technology base required to provide all-weather capability for civil and military aircraft. The focus of the instrumentation and controls technology is the development of nonintrusive research instrumentation and engine sensors/controls for the "smart" adaptive propulsion systems of the future. Hot section technology is aimed at providing improved durability and reliability of high temperature propulsion system components through the development of improved experimental and analytical tools.

In engine systems research, Lewis is developing focused propulsion technology for specific engines and propulsion systems. Research and technology in this area involves small engines (gas turbines and intermittent combustion engines), advanced turboprops (including a flight test planned for 1987), convertible engines, variable cycle engines, and new, innovative propulsion systems. Applications for this focused propulsion system research include subsonic transports, commuters, general aviation, rotorcraft, supersonic STOVL aircraft, and supersonic/hypersonic aircraft.

The Lewis aeropropulsion technology program is supported by advanced propulsion system studies and by propulsion facilities ranging from small research test rigs to large propulsion system altitude tanks and wind tunnels.

Permanent Civil
Service Workyears

TRANSATMOSPHERIC RESEARCH AND TECHNOLOGY...................................... 70

These activities at Lewis are directed toward understanding and defining a class of airbreathing propulsion systems, using hydrogen fuel, that are applicable to orbital accelerator and hypersonic cruise vehicles including the necessary advancements in variable geometry inlets and nozzles; characterizing a family of materials and cooling concepts compatible with extremely hot reusable engine and airframe structures; development of the computational methods necessary to analyze and define the flow in complex internal ducts and passages; and conducting the studies necessary to integrate these components into an efficient and capable propulsion system.

SPACE RESEARCH AND TECHNOLOGY... 345

The major roles of Lewis in space research and technology are to advance the state of the art and maintain a technology base for power systems, advanced primary and auxiliary propulsion, and space communications. This includes associated materials technology, structural analysis and life prediction technology, power management and distribution technology, and advanced development work in support of a space station, its evolutionary growth, satellites and other future space applications. In-space flight experiments are defined, developed and implemented in the context of the above technology areas and in the underlying basic sciences.

The Lewis primary propulsion programs emphasize the extension and advancement of the technologies of hydrogen- or hydrocarbon-fueled engines such as the space shuttle main engine toward long-life, reusable, serviceable systems for Earth-to-orbit applications. This concentrates on thrust chamber cooling and life, critical turbomachinery components, advanced structural analysis and life prediction and diagnostics.

Another thrust is to provide the technology for improving orbital transfer propulsion systems in the areas of performance, life and reusability. Emphasis is on combustion and heat transfer, long-life lightweight reusable components, and high expansion area nozzles. Arcjets are also being investigated.

The Lewis auxiliary propulsion programs are directed toward space station and satellite applications. Technologies for gaseous hydrogen-oxygen thrusters, resistojets capable of using various fuels, inert gas ion, and storable chemical engines are being explored.

Lewis does basic science and technology work and conducts in-space science and technology experiments in materials, combustion and fluid dynamics in reduced gravity. This activity is coordinated with the scientific community in universities, industry, and government. Critical space experiments in support of power and propulsion systems technology advances are also carried out.

Space power programs are directed toward evolutionary space station, satellite and other future space mission needs. This includes solar photovoltaic, solar dynamic, electrochemical energy conversion and storage, nuclear energy conversion, and power component and circuit development. The photovoltaic program seeks improvement in solar cell efficiency and life at reduced cost. In solar dynamics a higher efficiency alternative that reduces weight and area to high power levels is sought. Electrochemical research supports extended operating life and improved energy density for batteries and fuel cells. The nuclear energy conversion program is directed toward the development of advanced static and dynamic thermal energy conversion technologies and associated subsystems.

Power component and circuit technology for multihundred kilowatt power systems is being investigated. The interactions of the space plasma environment with power systems are also being studied.

The space communications program includes applied research and advanced development in microwave electron beam amplifiers, microwave solid-state devices, and antenna systems. The program consists of efforts to develop advanced concepts, techniques, and communications systems components which will enable growth in the utilization of the radio frequency spectrum to frequencies well beyond 100GHz.

The Lewis program in space materials and structures research and technology emphasizes the development of improved materials, advanced structural analysis and life prediction for advanced space power generation, propulsion and communications systems.

Permanent Civil
Service Workyears

SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS

SPACE TRANSPORTATION OPERATIONS.. 50

This program is responsible for the delivery to specified orbit of all spacecraft launched by the Atlas/Centaur vehicle. The program includes the procurement of vehicle systems hardward, launch services, and engineering and management support, as well as development, maintenance and operation of ground support equipment. In 1986 civil service personnel working in the Atlas/Centaur launch vehicle program will support one FLTSATCOM program launches. Following the final FLTSATCOM launch in the third quarter of 1987, an orderly phaseout of the Atlas/Centaur project will be initiated.

CENTER MANAGEMENT AND OPERATIONS SUPPORT................................. 527

Center Management and Operations Support is defined as support or services being provided to all Lewis organizations which cannot be directly identified to a benefiting program or project. The Civil Service personnel involved are:

Director and Staff - The Center Director, Deputy Director, and immediate staff, e.g., Technology Utilization, Equal Opportunity, Public Affairs, and Commercial Use of Space.

Management Support - Those who provide information and control services supporting all levels of Center program and functional management. Specific functions include resources planning and management, legal and patent counsel, contracting and procurement, personnel management, property management, financial management, and management information systems and analysis.

Operations Support - Those who provide for the operation and maintenance of institutional facilities, buildings, systems, and equipment, including those who manage or provide technical services such as general automatic data processing, reliability and quality assurance, medical care, and graphics support.

RESOURCES REQUIREMENTS BY FUNCTION

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
I. **PERSONNEL AND RELATED COSTS**.................	110,068	112,741	111,482	112,842
Summary of Fund Requirements				
A. Compensation and Benefits				
1. Compensation				
a. Full-time permanent..................	93,995	95,267	95,935	97,152
b. Other than full-time permanent......	1,238	2,370	785	816
c. Overtime and other compensation.....	1,975	1,988	2,100	2,059
Subtotal, Compensation..............	97,208	99,625	98,820	100,027
2. Benefits................................	11,681	12,111	11,398	11,233
Subtotal, Compensation and Benefits	108,889	111,736	110,218	111,260
B. Supporting Costs				
1. Transfer of personnel...................	45	75	15	15
2. Personnel training.......................	1,134	930	1,249	1,567
Subtotal, Supporting Costs.........	1,179	1,005	1,264	1,582
Total, Personnel and Related Costs......	110,068	112,741	111,482	112,842

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
A. Compensation and Benefits..................	108,889	111,736	110,218	111,260
1. Compensation............................	97,208	99,625	98,820	100,027
a. Full-time permanent.................	93,995	95,267	95,935	97,152

The increase from the 1986 budget estimate to the 1986 current estimate reflects the current distribution between permanent and other FTEs.

Basis of Cost for Civil Service Workyears

In 1987, the cost of permanent workyears will be $97,152,000. The increase from the 1986 level results from the following:

Cost of full-time permanent workyears in 1986..............................		95,935
Cost of increases in 1987..		2,305
Within grade and career development advances:		
Full year effect of 1986 actions................................	1,020	
Partial year effect of 1987 actions.............................	1,088	
Effect of 1986 decrease in offsetting reimbursements.......................		197
Cost of decreases in 1987..		-1,088
Turnover saving:		
Full year effect of 1986 actions................................	-961	
Partial year effect of 1987 actions.............................	-127	
Cost of full-time permanent workyears in 1987..............................		97,152

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
b. Other than full-time permanent				
1. Cost..............................	1,238	2,370	785	816
2. Workyears.........................	85	123	49	52

The distribution of 1987 workyears is as follows:

Distribution of Other Than Full-Time Permanent Workyears

Program	Workyears
Development programs..	16
Youth opportunity programs..	13
Other temporary...	23
Total...	52

The reduction from the 1986 budget estimate to the 1986 current estimate is due to a realignment between permanent and other FTEs. The increase in 1987 is the full year effect of that planned realignment.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
c. Overtime and other compensation.......	1,975	1,988	2,100	2,059

The increase from the 1986 budget estimate to the 1986 current estimate reflects an overtime plan consistent with the facility use schedule. The decrease in 1987 reflects estimated requirements.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Benefits................................	11,681	12,111	11,398	11,233

The following are the amounts of contribution by category:

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Civil Service Retirement Fund.........	6,653	6,660	6,442	6,485
Employee life insurance................	215	255	220	212
Employee health insurance.............	2,856	3,026	2,935	2,883
Workmen's compensation................	590	587	587	469
FICA..................................	212	304	100	100
Medicare..............................	1,137	1,259	1,095	1,076
Other benefits........................	18	20	19	8
Total.................................	11,681	12,111	11,398	11,233

The decrease from the 1986 budget estimate to the 1986 current estimate is primarily due to a decrease in Civil Service retirement, FICA, and medicare. The 1987 budget estimate reflects changes in compensation.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Supporting Costs...........................	1,179	1,005	1,264	1,582
1. Transfer of personnel..................	45	75	15	15

The decrease from the 1986 budget estimate to the 1986 current estimate is primarily due to an anticipated lower number of relocations.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Personnel training......................	1,134	930	1,249	1,567

The purpose of the training program is to provide for the development and education of civil service employees to more efficiently support Lewis roles and missions. The 1986 current estimate increase is a result of Lewis' emphasis on the skills needed to support acquisition of the power system for the Space Station and additional training in the areas of office automation. The 1987 budget estimate increase reflects a continuing growth in these areas at anticipated tuition costs.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
II. TRAVEL	2,626	2,726	2,622	2,897

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	1,722	2,097	1,993	2,239
B. Scientific & Tech. Development Travel	450	410	410	428
C. Management & Operations Travel	454	219	219	230
Total, Travel	2,626	2,726	2,622	2,897

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	1,722	2,097	1,993	2,239

Program travel is directly related to the accomplishment of the Center's mission and accounts for approximately 71% of travel costs. These funds are necessary for the management of major contractual programs in aeronautical research and technology, Space Station, space propulsion, materials research and development and space energy processes and systems technology. Program travel is also essential to the management and procurement of launch vehicles. The decrease from the 1986 budget estimate to the 1986 current estimate reflects a realignment of program requirements. The 1987 estimate reflects essentially the same level of travel at anticipated rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Scientific & Tech. Development Travel	450	410	410	428

Scientific and technical development travel provides employees the opportunity to participate in meetings and seminars with other representatives of the aerospace community. The benefits derived from exposure to technological advances outside Lewis, as well as to present both accomplishments and problems to their associates is invaluable. Many of the meetings are working panels convened to solve problems for the benefit of the Government. The 1987 estimate provides for continuation of travel at the 1986 current level of support with anticipated rate increases.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
C. Management & Operations Travel.........	454	219	219	230

Management and operations travel is required for the direction and coordination of general management matters. It includes travel in such areas as personnel, financial management, procurement, travel of the Center's top management to NASA Headquarters and other NASA Centers, training travel, and local transportation. The 1987 estimate provides for a level number of trips at anticipated rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
III. OPERATION OF INSTALLATION..............	24,689	29,318	28,873	34,581

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Facilities Services................	16,946	22,757	21,507	24,503
B. Technical Services.................	2,409	2,209	3,014	3,856
C. Management & Operations............	5,334	4,352	4,352	6,222
Total, Operation of Installation...	24,689	29,318	28,873	34,581

Explanation of Fund Requirements

Operation of Installation provides a broad range of services, supplies and equipment in support of the Center's institutional activities. These are divided into three major functional areas: (1) Facilities Services, the cost of maintaining and repairing institutional facilities and equipment, and the cost of custodial services and utilities; (2) Technical Services, the cost of automatic data processing for management activities and the cost of educational and informational programs and technical shops supporting institutional activities; and (3) Management and Operations, the cost of administrative communications, reproduction, printing, transportation, medical services and supplies.

The decrease from 1986 budget estimate to the 1986 current estimate is due primarily to the delay and deferral of activities and a rephasing of support contractor funding plans. The increase in 1987 includes rate increases for energy, support contracts, and the full year funding of support contracts begun in 1986.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
A. FACILITIES SERVICES....................	16,946	22,757	21,507	24,503

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Maintenance & Related Services.....	3,101	4,300	3,145	3,532
2. Custodial Services.................	3,258	4,429	4,258	4,788
3. Utility Services...................	10,587	14,028	14,104	16,183
Total, Facilities Services.......	16,946	22,757	21,507	24,503

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Maintenance and Related Services...	3,101	4,300	3,145	3,532

This activity provides for the operation and maintenance of facilities at the main installation in Cleveland and at the Plum Brook Station. Facilities maintenance includes buildings and ground maintenance and maintenance of heating, ventilating, and air-conditioning systems and equipment. The decrease from the 1986 budget estimate to the 1986 current estimate reflects deferral of planned maintenance increases. The 1987 estimate reflects anticipated service contractor wage rate increases.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Custodial Services.................	3,258	4,429	4,258	4,788

Security and janitorial services are provided by support contractors. Other services include rubbish disposal and industrial cleaning of walls and lights on an as needed basis. The decrease from the 1986 budget estimate to the 1986 current estimate is due primarily to lower support service contractor rates than originally anticipated. The increase in the 1987 budget estimate is due to anticipated rate changes in support service contracts and a small increase in workyears.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
3. Utility Services..................	10,587	14,028	14,104	16,163

Electrical power is provided by the local utility company. Natural gas is the primary heating fuel with oil as a backup fuel. A support contractor operates the central heating plant. The increase from the 1986 budget estimate to the 1986 current estimate is due to slightly higher utility rates than originally anticipated. The increase from 1986 to 1987 is attributable to anticipated higher electrical consumption, utility rate increases, and expected growth of support contractor rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Technical Services....................	2,409	2,209	3,014	3,856

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing	1,710	1,511	2,258	3,085
a. Equipment......................	936	375	692	1,386
b. Operations.....................	774	1,136	1,566	1,699
2. Scientific and Technical Information	699	698	756	771
Total, Technical Services........	2,409	2,209	3,014	3,856

Explanation of Fund Requirements

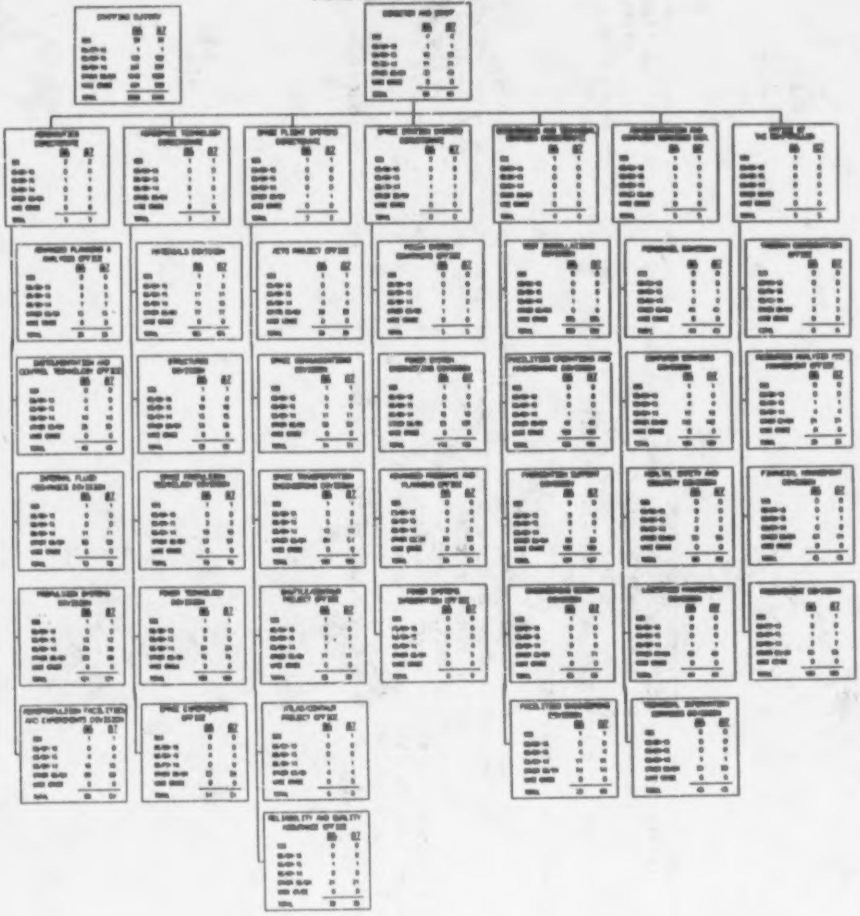
	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing..........	1,710	1,511	2,258	3,085

Funding provides for administrative data processing, including maintenance and periodic replacement of equipment, and operations. The 1986 current estimate reflects increased funding for support service contractors to provide support in business system analysis and design. The increase in 1987 is due to anticipated rate increases and the purchase of an upgraded central processing unit.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LEWIS RESEARCH CENTER

ORGANIZATION AND STAFFING CHART



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	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
2. Scientific and Technical Information..	699	698	756	771

Included in this activity is the support of the Center's educational programs and public information services. Funding for operation of the Visitor Information Center (VIC), conduct of tours and special events, construction and transport of special exhibits, and related activities are also included. The increase from the 1986 budget estimate to the 1986 current estimate is the result of a revised VIC exhibit upgrading program. The 1987 budget estimate provides for continuation of the 1986 VIC exhibit upgrading program.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
C. MANAGEMENT AND OPERATIONS....................	5,334	4,352	4,352	6,222

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications...........	639	405	677	599
2. Transportation...........................	1,469	1,886	1,795	2,110
3. Installation Common Services............	3,226	2,061	1,880	3,513
Total, Management and Operations.......	5,334	4,352	4,352	6,222

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications...........	639	405	677	599

This estimate provides local and long distance telephone service and non-telephone communications. Local telephone service includes the leased lines and equipment to serve the Center population. Non-telephone communications include telex, advanced record system teletype, rapidfax, datafax, teleconference equipment, oceanic cable service, and usage charges for airline reservation service. The increase in the 1986 current estimate is based on 1985 experience adjusted for rate increases in local and FTS services. The decrease for 1987 is based on lower costs associated with a new telephone system.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
2. Transportation........................	1,469	1,886	1,795	2,110

This activity includes the cost of the support contract for bus, mail and package delivery, stock issuance and administrative aircraft maintenance. It also includes moving and hauling services and motor vehicle purchase and maintenance. The decrease from the 1986 budget estimate to the 1986 current estimate reflects deferral in the purchase of motor vehicles. The increase in 1987 is anticipated contractor wage rates, increase in fuel rates, and the purchase of motor vehicles deferred from 1986.

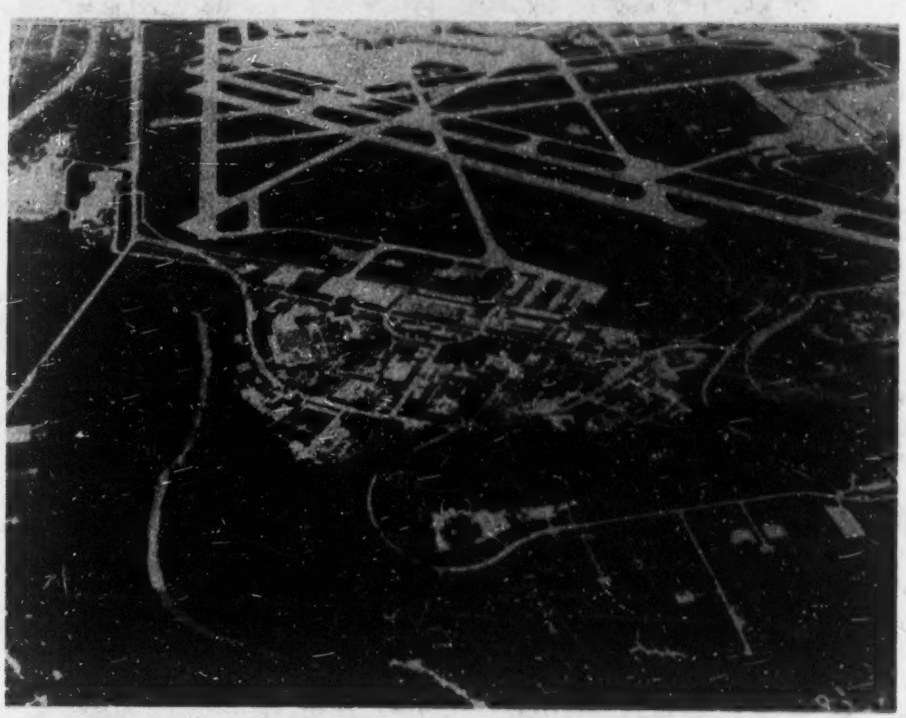
3. Installation Common Services...........	3,226	2,061	1,880	3,513

This funding provides minor administrative services for Center management and staff at Plum Brook Station. Also, included is the cost of staff medical examinations, clinic support, medical supplies and equipment special x-ray equipment for the in-house occupational health program, and equipment for the physical fitness facility. All of these services are provided by a support contractor. This function also included funding for maintenance and periodic replacement of administrative equipment and supplies, and postage. The decrease from the 1986 budget estimate to the 1986 current estimate is due to a rephasing of the support contractor funding plan. The increase in the 1987 budget estimate reflects a full year funding for support contracts at anticipated rate increases and the adjustment between direct and reimbursable funding.

LEWIS RESEARCH CENTER

FISCAL YEAR 1987 ESTIMATES

CLEVELAND FACILITIES



LEWIS RESEARCH CENTER

FISCAL YEAR 1987 ESTIMATES

PLUM BROOK FACILITIES

RPM 8-23

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987 ESTIMATES

NASA HEADQUARTERS

DESCRIPTION

NASA Headquarters is located at 400 Maryland Avenue, SW, Washington, D.C., and occupies other buildings in the District of Columbia and Maryland.

HEADQUARTERS ROLES AND MISSIONS

The mission of Headquarters is to plan and provide executive guidelines for the implementation of national space and aeronautics programs consistent with the objectives stated in the National Aeronautics and Space Act of 1958, as amended. These objectives are to:

--Extend our knowledge of the Earth, its environment, the solar system, and the universe;

--Expand practical applications of space technology;

--Develop, operate, and improve manned and unmanned space vehicles;

--Improve the civil and military usefulness of aeronautical vehicles, while minimizing their environmental effects and energy consumption;

--Disseminate pertinent findings to potential users; and

--Promote international cooperation in peaceful activities in space.

The following offices at Headquarters assist management in carrying out the technical aspects of the mission:

Office of Space Flight - Plans, directs, executes, and evaluates the research, development, acquisition and operation of space flight programs. Included in these programs is the Space Shuttle, an essential element of the Space Transportation System (STS). Also included in the STS are the orbiters, engines, external tanks, solid rocket boosters, upper stages and ground and flight systems. This office develops and implements policy for all system users to interface with STS. Responsibilities also include development and implementation of appropriate transition policies for expendable launch vehicles to be transferred from the

Government to the private sector. The Office of Space Flight promotes improvements in effectiveness, cost efficiency and timeliness of STS operational performance. This office also maintains relationships with industry, international organizations, foreign entities, universities, the scientific community, and other Government agencies with respect to the space flight program, including the Spacelab program, in coordination with the Office of External Relations.

Office of Space Station - Responsible for establishing program policy, budget schedule guidelines, and for coordinating and interfacing with external organizations. This office is also responsible for providing program direction and management, program requirements definition and control, utilization and operations planning, programmatic planning and implementation, and advanced technology development program coordination.

Office of Space Science and Applications - Responsible for research and development efforts utilizing a variety of flight system and ground-based observations to increase man's knowledge of the universe. The Earth, Sun, Moon, the planets, interplanetary space, other stars and galaxies, and the interaction among those bodies and systems are all objects of these investigations, as well as assuring medical safety and understanding the basic mechanisms of biological processes using the unique capabilities of the space program. Responsibilities also include conducting research and development activities leading to demonstration and transfer of space-related technology and capabilities which can be effectively applied and used for practical benefits on Earth. These research and development activities involve the following program areas: earth observations, environmental observations, communications, material processing in space, and information systems.

Office of Aeronautics and Space Technology - Plans, directs, executes, and evaluates the aeronautical and space research and technology programs as well as the transatmospheric research and technology program. The aeronautics program develops technology culminating in safer, more efficient, economical and environmentally acceptable air transportation systems which are responsive to national needs. The space research and technology program provides a technology base which anticipates the technical needs and provides technology options for future space activities. NASA's portion of a joint NASA/DOD program for transatmospheric research and technology will accelerate the development and validation of key technologies to form the critical data base required for the design and integration of complex propulsion and structural systems for transatmospheric vehicles. This office coordinates the total NASA program of supporting research and technology related to specific programs and projects to insure a comprehensive, properly balanced agency research and technology program.

Office of Space Tracking and Data Systems - Develops, implements, and operates tracking, data acquisition, command, communications, and data processing facilities, systems and services required for support of all NASA flight missions. This office also provides centralized planning and systems management for administrative communications between NASA installations.

Office of Commercial Programs - Provides a focus within NASA for an agencywide program supporting the expansion of U.S. private sector investment and involvement in civil space activities, for space commercial user development, for actively supporting new high technology commercial space ventures and for the commercial application of existing aeronautics and space technology.

The NASA Headquarters' administrative and staff offices' responsibilities include: planning, formulating, and advocating executive direction for national programs to implement the objectives stated in the National Aeronautics and Space Act of 1958, as amended; and administering and providing operational and logistical support to those Headquarters elements concerned with carrying out the mission of NASA.

The Headquarters workforce consists of professional and clerical staff organized into the above specified program offices and appropriate supporting staff offices. Each office is assigned a function consistent with NASA the mission. The number of personnel authorized to an office is determined by management based on the approved personnel ceiling for the Agency and the functions to be performed. The composition of the staff of an office is determined by the head of the office based on the office ceiling and the function to be performed. All personnel are appointed and paid consistent with classification standards established by the Office of Personnel Management. Overall Agency direction is provided by the Administrator, and his personal office staff. The Agency currently has eight installations, and the Jet Propulsion Laboratory, throughout the United States which perform Agency operational missions under direction of the Headquarters staff.

SUMMARY OF RESOURCES REQUIREMENTS

Funding Plan by Function

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands	of Dollars)	
I. Personnel and Related Cost....	72,774	74,609	73,519	73,701
II. Travel........................	4,623	5,000	5,187	5,355
III. Operation of Installation.....	39,469	40,411	40,460	48,840
A. Facilities Services........	(10,815)	(10,027)	(10,975)	(13,691)
B. Technical Services.........	(17,504)	(17,887)	(16,962)	(21,426)
C. Management and Operations..	(11,150)	(12,497)	(12,523)	(13,723)
Total, fund requirement.	116,866	120,020	119,166	127,896

Distribution of Permanent Workyears by Program

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
RESEARCH AND DEVELOPMENT	387	417	409	409
Space Station	53	72	68	68
Space Transportation Capability Development	24	24	22	22
Space Science and Applications	181	175	178	178
Physics and astronomy	52	50	50	50
Life sciences	24	24	25	25
Planetary exploration	24	24	25	25
Space applications	81	77	78	78
Commercial Programs	22	36	38	38
Technology Utilization	5	12	10	10
Commercial Use of Space	17	24	28	28
Aeronautics and Space Technology	104	107	100	100
Aeronautical research and technology	62	64	60	58
Space research and technology	42	43	40	40
Transatmospheric research and technology	---	---	---	2
Tracking and Data Advanced Systems	3	3	3	3
SPACE FLIGHT CONTROL AND DATA COMMUNICATIONS	181	181	169	169
Shuttle Production and Operational Capability	20	20	19	19
Space Transportation Operations	114	112	105	105
Space and Ground Network Communications and Data Systems	47	49	45	45
Subtotal, direct workyears	568	598	578	578
CENTER MANAGEMENT AND OPERATIONS SUPPORT	699	694	664	664
Total, full-time permanent workyears	1,267	1,292	1,242	1,242
Other than full-time permanent workyears	118	125	115	115
Total, Workyears	1,385	1,417	1,357	1,357

RESOURCES REQUIREMENTS BY FUNCTION

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS	72,774	74,609	73,519	73,701

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Compensation and Benefits				
1. Compensation				
a. Full-time permanent	57,275	60,164	57,292	57,454
b. Other than full-time permanent	2,925	2,416	3,021	2,809
c. Reimbursable detailees	604	461	520	724
d. Overtime and other compensation	1,794	1,622	1,839	1,875
Subtotal, Compensation	62,598	64,663	62,672	62,862
2. Benefits	6,874	6,994	7,304	7,044
Subtotal, Compensation & Benefits	69,472	71,657	69,976	69,906
B. Supporting Costs				
1. Transfer of personnel	355	165	358	365
2. Office of Personnel Management Services	708	844	880	881
3. Personnel training	2,239	1,943	2,305	2,549
Subtotal, Supporting Costs	3,302	2,952	3,543	3,795
Total, Personnel and Related Costs	72,774	74,609	73,519	73,701

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
A. Compensation and Benefits	69,472	71,657	69,976	69,906
1. Compensation	62,598	64,663	62,672	62,862
a. Full-time permanent	57,275	60,164	57,292	57,454

The decrease in the compensation estimate from the 1986 budget estimate to the 1986 current estimate is due to a decrease in the FTE allocation.

Basis of Cost for Permanent Positions

In 1987 the cost of permanent workyears will be $57,454,000. The increase from 1986 results from the following:

Cost of full-time permanent workyears in 1986		57,292
Cost increases in 1987		1,206
Within grade and career advances:		
Full year effect of 1986 actions	441	
Partial year effect of 1987 actions	765	
Cost decreases in 1987		-1,044
Turnover savings and abolished positions:		
Full year effect of 1986 actions	-823	
Partial year effect of 1987 actions	-221	
Cost of full-time permanent workyears in 1987		57,454

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
b. Other than full-time permanent				
(1) Cost	2,925	2,416	3,021	2,809
(2) Workyears	141	147	137	137

The distribution of 1987 workyears is as follows:

Distribution of Other Than Full-Time Permanent Workyears

Program	Workyears
Development programs	30
Summer employment programs	7
Youth opportunity programs	22
Other temporary	78
Total	137

The increase from the 1986 budget estimate to the 1986 current estimate reflects an increase in developmental programs, such as Presidential Management Internships, which are higher graded than cooperative education and temporary employment programs. The 1987 estimate is essentially level with 1986 except for adjustments to the mix between the various programs.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
c. Reimbursable detailees	604	461	520	724

The services of a small group of military officers and civilian detailees from other government agencies are used by NASA Headquarters where such assignments are of mutual benefit. The increase from the 1986 budget estimate to the 1986 current estimate is due to adjustments for 1985 actual experience. The increase from the 1986 current estimate to the 1987 budget estimate results from the inclusion of military retirement in the detailee cost formula.

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
d. Overtime and other compensation.........	1,794	1,622	1,839	1,875

The increase from the 1986 budget estimate to the 1986 current estimate reflects 1985 experience. The increase from the 1986 current estimate to the 1987 budget estimate is due to rate increases for relatively the same level of effort as 1986.

2. Benefits..................................	6,874	6,994	7,304	7,044

The following are the amounts of contribution by category:

Civil Service Retirement Fund...........	4,032	4,253	4,066	4,091
Employee life insurance..................	194	151	142	143
Employee health insurance...............	1,251	1,291	1,258	1,266
Workmen's compensation.................	436	412	825	531
FICA....................................	170	119	206	197
Medicare.................................	596	611	645	654
Other benefits.........................	195	157	162	162
Total............................	6,874	6,994	7,304	7,044

The increases in the 1986 current estimate from the 1986 budget estimate is primarily due to updated pricing of workman's compensation and adjustments for the effects of changes in Civil Service retirement estimate. The 1987 budget estimate reflects an expected decrease in workmen's compensation.

B. Supporting Costs............................	3,302	2,952	3,543	3,795
1. Transfer of personnel..................	355	165	358	365

The costs associated with transfer of personnel include movement of household goods, subsistence and temporary expenses, real estate and miscellaneous moving expenses related to change of duty station. The increase from the 1986 budget estimate to the 1986 current estimate reflects an increased number of expected relocations. The 1987 budget estimate reflects essentially the same number of relocations as in 1986.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Office of Personnel Management services..	708	844	880	881

Headquarters reimburses the Office of Personnel Management (OPM) for investigation of new hires for the entire Agency. The cost of investigations is a function of two variables, the number of investigations to be conducted, and the unit charge made by the Office of Personnel Management to other agencies. Also included is a payment to OPM for Federal wage system surveys. The increases are driven by new OPM guidelines calling for background investigations on a greater number of employees.

3. Personnel training......................	2,239	1,943	2,305	2,549

The maintenance and expansion of skills is essential in carrying out the Agency's many complex technical programs. Part of the training consists of courses offered by other Government agencies, usually for a fee. The remainder of the training is provided through nongovernment sources. The costs are for tuition, fees and related costs for training at colleges, universities, technical institutions, and for the cost of seminars and workshops in which groups of Headquarters and Field Center employees receive training in subjects of Agencywide interest. The increase from the 1986 budget to the 1986 current estimate reflects increased emphasis on supervisory and management effectiveness and ADP proficiency training. The 1987 budget estimate provides for the same level of training at anticipated cost levels.

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	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
II. TRAVEL	4,623	5,000	5,187	5,355

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	3,065	3,371	3,563	3,679
B. Scientific and Technical Development Travel	573	676	674	696
C. Management and Operations Travel	985	953	950	980
Total, Travel	4,623	5,000	5,187	5,355

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Program Travel	3,065	3,371	3,563	3,679

Program travel funds are used in support of NASA's research and development programs, such as the Space Station, the Space Transportation System, Aeronautics and Space Technology, Space Science and Applications, and other direct research and development programs. This category represents approximately 66 percent of the Headquarters travel requirements for 1986. The increase from the 1986 budget estimate to the 1986 current estimate reflects the need for increased program travel to accomplish the agency's missions. The 1987 budget estimate provides for the same level of program travel as 1986 with adjustments for increases in travel expenses.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
B. Scientific and Technical Development Travel	573	676	674	696

Scientific and technical development travel permits employees to participate in meetings and seminars with other representatives of the aerospace community. This participation allows personnel to benefit from exposure to technological advances in the field which arise outside NASA, as well as to present both accomplishments and problems to their associates. Many of these meetings are working panels covened to solve certain problems for the benefit of the Government. The increase in the 1987 budget estimate from the 1986 current estimate is due to projected increases in travel expenses for the same level of travel.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
C. Management and Operations Travel..............	985	953	950	980

Management and operations travel is for the direction and coordination of general management matters, travel by senior officials to review Center requirements and operations and career development travel in order to broaden the experience of NASA employees. Management and operations travel includes travel by functional managers in such areas as personnel, financial management, and procurement to assure Agency policies and procedures are being implemented throughout the agency. Also included is local transportation and congressional travel. The increase in the 1987 budget estimate from the 1986 current estimate is due to projected increases in travel expenses for the same level of travel.

	1985	1986		1987
	Actual	Budget Estimate	Current Estimate	Budget Estimate
III. OPERATION OF INSTALLATION	39,469	40,411	40,460	48,840

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Facilities Services	10,815	10,027	10,975	13,691
B. Technical Services	17,504	17,887	16,962	21,426
C. Management and Operations	11,150	12,497	12,523	13,723
Total, Operation of Installation	39,469	40,411	40,460	48,840

Explanation of Fund Requirements

Operation of Installation provides a broad range of services, supplies, and equipment in support of the Headquarters' institutional activities. These are divided into three major functional areas: Facilities Services, rental of real property, acquisition, maintenance and repair of institutional facilities and equipment, and the cost of custodial services; Technical Services including the, cost of automatic data processing for management activities, and the cost of educational and informational programs and technical shops supporting institutional activities; and Management and Operations, the cost of administrative communications, printing, transportation, medical supplies, and related services.

The increase from the 1986 budget estimate to the 1986 current estimate is primarily due to increases in facility rentals and maintenance costs, offsetting a decrease in support contracts due to a rephasing of obligation plans. The 1987 budget estimate is considerably higher due to a significant increase in facility rental costs, the replacement of a critically needed administrative main-frame computer and full year funding for support service contracts.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. FACILITIES SERVICES	10,815	10,027	10,975	13,691

NASA Headquarters is comprised of a complex of buildings in the District of Columbia and Maryland. These are government-owned and leased buildings for which NASA must provide reimbursement to the General Services Administration (GSA) in accordance with P.L. 92-313. The cost of temporary use of off-site facilities is also included in this category.

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
1. Rental of Real Property	8,117	8,074	8,148	10,648
2. Maintenance and Related Services	2,096	1,192	2,073	2,266
a. Facilities	2,096	1,192	2,073	2,266
b. Equipment	---	---	---	---
3. Custodial Services	602	761	754	777
Total, Facilities Services	10,815	10,027	10,975	13,691

Explanation of Fund Requirements

1. Rental of Real Property	8,117	8,074	8,148	10,648

Public Law 92-313 requires that agencies be charged for space and related services provided by the General Services Administration at approximate commercial equivalent rates. These funds provide for the cost of office space used by NASA Headquarters personnel. The increase from the 1986 budget estimate to the 1986 current estimate is due to a delay in planned reduction of NASA Headquarters office space. The increase from the 1986 current estimate to the 1987 budget estimate is due to an increase in rental rates as projected by GSA.

2. Maintenance and Related Services	2,096	1,192	2,073	2,266

This estimate includes maintenance, repair and alterations of buildings such as partition changes, auxilliary air conditioning systems for ADP equipment, telephone changes and general buildings maintenance. The increase in 1986 from the budget estimate reflects a recategorization of support contract costs related to facilities maintenance to more accurately reflect the actual cost of Headquarters facilities. The increase to the 1987 budget estimate provides for essentially the 1986 level of service.

	1985 Actual	1986 Budget Estimate	 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
3. Custodial Services........................	602	761	754	777

These funds cover security guard services in the various Headquarters buildings. They also include reimbursement to GSA for the installation and maintenance of security alarm systems and equipment in the NASA Headquarters buildings. The 1986 current estimate reflects increased rates as projected by GSA and additional security in order to furnish adequate protection for classified defense information, government/personal property, and NASA employees. The 1987 budget estimate reflects GSA projected rates for essentially the same level of support as 1986.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
B. TECHNICAL SERVICES	17,504	17,887	16,962	21,426

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automation Data Processing	13,386	13,642	12,690	17,145
a. Equipment	2,845	2,902	1,562	7,016
b. Operations	10,541	10,740	11,128	10,129
2. Scientific and Technical Information	3,066	3,188	3,334	3,306
a. Library	441	418	488	508
b. Education and Information	2,625	2,770	2,846	2,798
3. Shop and Support Services	1,052	1,057	938	975
Total, Technical Services	17,504	17,887	16,962	21,426

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Automatic Data Processing	13,386	13,642	12,690	17,145

This estimate provides for the lease, purchase, maintenance, programming and operations services of automatic data processing (ADP) equipment. The small decrease from the 1986 budget estimate to the 1986 current estimate reflects increasing contractor wage rates offset by the effects of one time expenditures for ADP equipment in 1985. The 1987 estimate provides for approximately the same level of services as in 1986 plus the critically needed replacement of the Headquarters administrative computer, a 1972 model IBM 370.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Scientific and Technical Information	3,066	3,188	3,334	3,306

The activities contained in this subfunction are educational-informational programs and the NASA Headquarters technical library.

The education and information programs provide for gathering and disseminating information about the Agency's programs to the mass communications media, the general public, and to the educational community at the elementary and secondary levels. Assistance to the mass communications media includes the gathering and exposition of newsworthy material in support of their requests, and takes such forms as press kits, news releases, television and radio information tapes and clips, and feature material. Research, development, and operational missions in aeronautics and space provide substantive knowledge and serve as an educational stimulus to students and teachers. NASA responds to expressed needs of students by developing curriculum supplements in space-related areas such as physics, biology, chemistry, and math; assistance to over 1,000 teacher workshops and professional education meetings; and participation in science fairs. This program also provides for equal employment opportunity exhibits and films to relate to high schools, colleges and the public, and the key roles that women and minorities have in the United States space program.

The increase in the 1986 current estimate over the 1986 budget estimate, and the subsequent decrease in the 1987 budget estimate reflect the one-year need for instructional materials and other efforts related to the flight of a school teacher on the Space Shuttle during 1986.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
3. Shop and Support Services................	1,052	1,057	938	975

These funds provide for the continuation of studies on parts applications, NASA-wide safety, reliability, quality assurance standards, graphic and photo processing services. The decrease in the 1986 current estimate from the 1986 budget estimate reflects a realignment of funding for productivity-related efforts. The 1987 estimate provides a continuation of essentially the same level of service provided in 1986 at anticipated rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
C. MANAGEMENT AND OPERATIONS....................	11,150	12,497	12,523	13,723

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications...........	2,799	3,584	3,183	3,257
2. Printing and Reproduction...............	1,266	1,352	1,307	1,339
3. Transportation..........................	472	584	610	673
4. Installat[illegible] Services............	6,613	6,977	7,423	8,454
Tota[illegible]ent and Operations.....	11,150	12,497	12,523	13,723

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
1. Administrative Communications...........	2,799	3,584	3,183	3,257

Included in this category are the costs of leased lines, long distance tolls, telephone exchange services, and other communications. The decrease in the 1986 current estimate from the 1986 budget estimate is projected from communication rates based on 1985 experience. The 1987 budget estimate reflects essentially the same effort as 1986 with adjustments for projected rate increases.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Printing and Reproduction...............	1,266	1,352	1,307	1,339

Administrative printing includes funds for contractual printing and the related composition and binding operations. This includes services performed by other agencies, chiefly the Government Printing Office, or by commercial printing firms. All common processes of duplicating including photostating, blueprinting, microfilming, and other reproductions are included. The decrease from the 1986 budget estimate to the 1986 current estimate reflects a reduction in the level of printing activity and 1985 experience. The 1987 budget estimate reflects essentially the same effort as 1986 at expected 1987 rates.

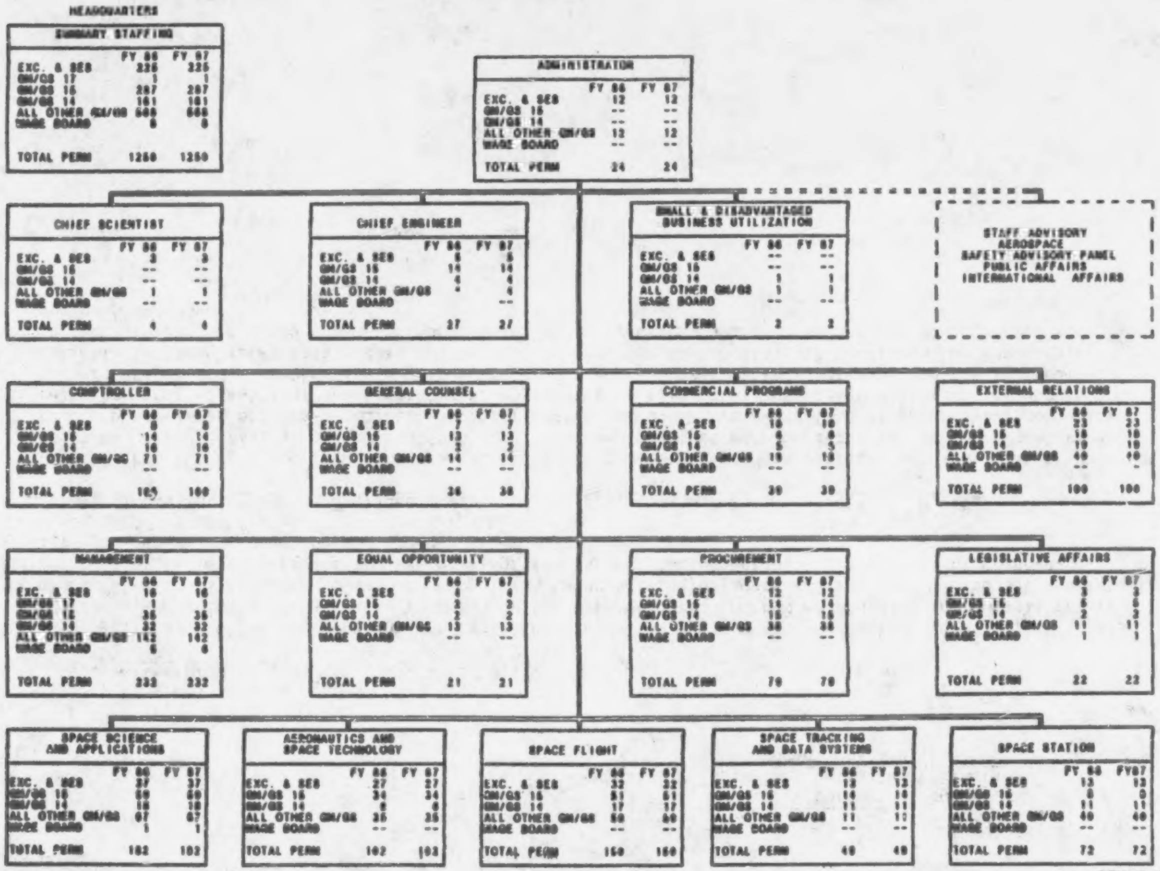
	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
3. Transportation...........................	472	584	610	673

Transportation services include rental of trucks, as well as the movement of supplies, materials, equipment and related items. Also included is the cost of operating and maintaining the administrative aircraft which is assigned to the Jet Propulsion Laboratory. The increase from the 1986 budget estimate to the current estimate reflects revised pricing expectations for essentially the same level of service. The increase in 1987 is based on 1986 levels at expected 1987 rates.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
4. Installation Common Services............	6,613	6,977	7,423	8,454

This function provides for those services which support the Headquarters, such as: patent services, maintenance and repair of office equipment and vehicles; minor Government services; contract histories; trucking and labor services; medical services; contractor incentive awards; Equal Opportunity community relations and fellowships; Administrator's representation allowance; overseas administration support and documentation; and adminstrative supplies, materials and equipment. The increase from the 1986 budget estimate to the current estimate is due to support provided to the National Commission on Space. The increase in 1987 is based on an increased level of contractor support in such areas as logistics and equipment management.

ORGANIZATION AND STAFFING
NASA HEADQUARTERS



HEADQUARTERS SUMMARY STAFFING

	FY 86	FY 87
EXC. & SES	225	225
GM/GS 17	1	1
GM/GS 15	287	287
GM/GS 14	161	161
ALL OTHER GM/GS	568	568
WAGE BOARD	8	8
TOTAL PERM	1250	1250

ADMINISTRATOR

	FY 86	FY 87
EXC. & SES	12	12
GM/GS 15	--	--
GM/GS 14	--	--
ALL OTHER GM/GS	12	12
WAGE BOARD	--	--
TOTAL PERM	24	24

CHIEF SCIENTIST

	FY 86	FY 87
EXC. & SES	3	3
GM/GS 15	--	--
GM/GS 14	--	--
ALL OTHER GM/GS	1	1
WAGE BOARD	--	--
TOTAL PERM	4	4

CHIEF ENGINEER

	FY 86	FY 87
EXC. & SES	5	5
GM/GS 15	14	14
GM/GS 14	4	4
ALL OTHER GM/GS	4	4
WAGE BOARD		--
TOTAL PERM	27	27

SMALL & DISADVANTAGED BUSINESS UTILIZATION

	FY 86	FY 87
EXC. & SES	--	--
GM/GS 15	--	--
GM/GS 14	1	1
ALL OTHER GM/GS	1	1
WAGE BOARD	--	--
TOTAL PERM	2	2

STAFF ADVISORY
AEROSPACE
SAFETY ADVISORY PANEL
PUBLIC AFFAIRS
INTERNATIONAL AFFAIRS

COMPTROLLER

	FY 86	FY 87
EXC. & SES	8	8
GM/GS 15	14	14
GM/GS 14	16	16
ALL OTHER GM/GS	71	71
WAGE BOARD	--	--
TOTAL PERM	105	100

GENERAL COUNSEL

	FY 86	FY 87
EXC. & SES	7	7
GM/GS 15	13	13
GM/GS 14	2	2
ALL OTHER GM/GS	14	14
WAGE BOARD	--	--
TOTAL PERM	36	36

COMMERCIAL PROGRAMS

	FY 86	FY 87
EXC. & SES	10	10
GM/GS 15	6	6
GM/GS 14	5	5
ALL OTHER GM/GS	18	18
WAGE BOARD	--	--
TOTAL PERM	39	39

EXTERNAL RELATIONS

	FY 86	FY 87
EXC. & SES	23	23
GM/GS 15	18	18
GM/GS 14	19	19
ALL OTHER GM/GS	40	40
WAGE BOARD	--	-
TOTAL PERM	100	100

MANAGEMENT

	FY 86	FY 87
EXC. & SES	16	16
GM/GS 17	1	1
GM/GS 15	35	35
GM/GS 14	32	32
ALL OTHER GM/GS	142	142
WAGE BOARD	6	6
TOTAL PERM	232	232

EQUAL OPPORTUNITY

	FY 86	FY 87
EXC. & SES	4	4
GM/GS 15	2	2
GM/GS 14	2	2
ALL OTHER GM/GS	13	13
WAGE BOARD	--	--
TOTAL PERM	21	21

PROCUREMENT

	FY 86	FY 87
EXC. & SES	12	12
GM/GS 15	14	14
GM/GS 14	15	15
ALL OTHER GM/GS	38	38
WAGE BOARD	--	--
TOTAL PERM	79	79

LEGISLATIVE AFFAIRS

	FY 86	FY 87
EXC. & SES	3	3
GM/GS 15	5	5
GM/GS 14	2	2
ALL OTHER GM/GS	11	11
WAGE BOARD	1	1
TOTAL PERM	22	22

SPACE SCIENCE AND APPLICATIONS

	FY 86	FY 87
EXC. & SES	37	37
GM/GS 15	59	59
GM/GS 14	18	18
ALL OTHER GM/GS	67	67
WAGE BOARD	1	1
TOTAL PERM	182	182

AERONAUTICS AND SPACE TECHNOLOGY

	FY 86	FY 87
EXC. & SES	27	27
GM/GS 15	34	34
GM/GS 14	6	6
ALL OTHER GM/GS	35	35
WAGE BOARD	--	--
TOTAL PERM	102	102

SPACE FLIGHT

	FY 86	FY 87
EXC. & SES	32	32
GM/GS 15	51	51
GM/GS 14	17	17
ALL OTHER GM/GS	60	60
WAGE BOARD	--	--
TOTAL PERM	160	160

SPACE TRACKING AND DATA SYSTEMS

	FY 86	FY 87
EXC. & SES	13	13
GM/GS 15	14	14
GM/GS 14	11	11
ALL OTHER GM/GS	11	11
WAGE BOARD	--	--
TOTAL PERM	49	49

SPACE STATION

	FY 86	FY87
EXC. & SES	13	13
GM/GS 15	8	8
GM/GS 14	11	11
ALL OTHER GM/GS	40	40
WAGE BOARD	--	--
TOTAL PERM	72	72

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987 ESTIMATES

NASA OFFICE OF INSPECTOR GENERAL

DESCRIPTION

The NASA Office of Inspector General (OIG) is located at 400 Maryland Avenue, SW, Washington, D.C.. OIG field locations include offices at Ames Research Center, California; Goddard Space Flight Center, Maryland; Jet Propulsion Laboratory, California; Johnson Space Center, Texas; Kennedy Space Center, Florida; Langley Research Center, Virginia; Lewis Research Center, Ohio, and Marshall Space Flight Center, Alabama.

OFFICE OF INSPECTOR GENERAL ROLES AND MISSIONS

The NASA OIG was created in 1978 by an Act of Congress (P.L. 95-452) as an independent and objective unit within the Agency. The purposes and mission of the OIG are to:

-- Conduct and supervise audits and investigations relating to NASA's programs and operations;

-- Promote economy, efficiency, and effectiveness in the administration of these programs and operations;

-- Prevent and detect fraud and abuse in these programs and operations; and

-- Keep the NASA Administrator and the Congress fully and currently informed about NASA programs, deficiencies relating to the administration of such programs, and the necessity for and progress of corrective actions.

SUMMARY OF RESOURCES REQUIREMENTS

Funding Plan by Function

		1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)			
I.	Personnel and Related Cost.....	4,736	5,237	4,954	5,008
II.	Travel........................	218	252	239	245
III.	Operation of Installation......	271	329	318	241
	A. Facilities Services........	(---)	(---)	(---)	(---)
	B. Technical Services.........	(237)	(50)	(256)	(176)
	C. Management and Operations..	(34)	(279)	(62)	(65)
	Total, fund requirement...	5,225	5,818	5,511	5,494

Distribution of Permanent Civil Service Workyears

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Permanent full-time workyears........	94	97	97	97
Other than full-time................	9	10	10	10
Total workyears...............	103	107	107	107

RESOURCES REQUIREMENTS BY FUNCTION

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
I. PERSONNEL AND RELATED COSTS................	4,736	5,237	4,954	5,008

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Compensation and Benefits				
1. Compensation				
a. Full-time permanent.................	3,861	4,115	3,984	4,024
b. Other than full-time permanent......	156	202	180	185
c. Overtime and other compensation.....	5	5	5	5
Subtotal, Compensation............	4,022	4,322	4,169	4,214
2. Benefits................................	465	495	470	479
Subtotal, Compensation & Benefits.......	4,487	4,817	4,639	4,693
B. Supporting Costs				
1. Transfer of personnel...................	207	375	270	270
2. Personnel training......................	42	45	45	45
Subtotal, Supporting Costs............	249	420	315	315
Total, Personnel and Related Costs......	4,736	5,237	4,954	5,008

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
A. Compensation and Benefits.............	4,487	4,817	4,639	4,693
1. Compensation......................	4,022	4,322	4,169	4,214
a. Full-time permanent...........	3,861	4,115	3,984	4,024

Basis of Cost for Permanent Positions

In 1987 the cost of permanent workyears will be $4,024,000. The increase from 1986 results from the following:

Cost of full-time permanent workyears in 1986..........................		3,984
Cost Increases in 1987..		104
Within-grade and career advances:		
Full year cost of 1986 actions............................	54	
Part year cost of 1987 actions............................	50	
Cost Decreases in 1987..		-64
Turnover savings and abolished positions:		
Full year cost of 1986 actions............................	-35	
Part year cost of 1987 actions............................	-29	
Cost of full-time permanent workyears in 1987........................		4,024

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
b. Other than full-time permanent				
(1) Cost............................	156	202	180	185
(2) Workyears.......................	9	10	10	10

The distribution of 1987 workyears is as follows:

Distribution of Other Than Full-Time Permanent Workyears

Program	Workyears
Summer employment programs..................................	i
Other temporary...	9
Total...	10

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
c. Overtime and other compensation..	5	5	5	5
2. Benefits..................................	465	495	470	479

The following are the amounts of contributions by category:

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Civil Service Retirement Fund...........	281	300	283	286
Employee life insurance..................	10	11	10	10
Employee health insurance................	86	91	87	88
Workmen's compensation...................	32	33	33	36
FICA.....................................	16	18	12	13
Medicare.................................	40	42	45	46
Total....................................	465	495	470	479

The increase in the 1987 budget estimate from the 1986 current estimate is related to the increase in salaries.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
B. Supporting Costs	249	420	315	315
1. Transfer of personnel	207	375	270	270

The costs associated with the transfer of personnel include movement of household goods, subsistence and temporary expenses, real estate and miscellaneous moving expenses related to change of duty station. The reduction in the 1986 current estimate reflects 1985 actual experience. The 1987 budget estimate reflects essentially the same number of relocations as in 1986.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
2. Personnel training	42	45	45	45

The maintenance and expansion of skills is essential in carrying out the mission of the OIG. Part of the training consists of courses offered by other Government agencies, usually for a fee. The remainder of the training is provided through nongovernment sources. The costs are for tuition, fees and related expenses for training at colleges, universities, technical institutions, and for seminars and workshops. The 1987 budget estimate provides for the same level of training as 1986 at anticipated cost levels.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
II. TRAVEL................................	218	252	239	245

Summary of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Management and Operations Travel......	218	252	239	245
Total, Travel......................	218	252	239	245

Explanation of Fund Requirements

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Management and Operations Travel.........	218	252	239	245

Travel funding is required to conduct audits, investigations and management functions. The 1987 budget estimate represents the same level of travel as in 1986. The reduction from the 1986 budget estimate to the 1986 current estimate is based on 1985 experience.

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
III. OPERATION OF INSTALLATION................	271	329	318	241

Summary of Fund Requirements

A. Technical Services...................	237	50	256	176
B. Management and Operations............	34	279	62	65
Total, Operation of Installation...	271	329	318	241

Explanation of Fund Requirements

Operation of Installation provides a broad range of services, supplies, and equipment in support of the Inspector General's activities.

The decrease from the 1986 current estimate to the 1987 budget estimate is due to a reduction in the effort for automation of the Inspector General's Audit Operations.

A. Technical Services.........................	237	50	256	176

Summary of Fund Requirements

1. Automated Data Processing..............	237	50	256	176
Operations...........................	237	50	256	176
Total, Technical Services..........	237	50	256	176

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		

Explanation of Fund Requirements

1. Automated Data Processing	237	50	256	176

This estimate provides for the lease, purchase, maintenance, programming and operations services of automated data processing (ADP) equipment. The increase from the 1986 budget estimate to the 1986 current estimate reflects a continuing effort to modernize and automate the OIG audit capabilities. This effort peaks in 1986 resulting in the decrease in 1987.

B. Management and Operations	34	279	62	65

Summary of Fund Requirements

1. Administrative Communications	20	21	21	22
2. Printing and Reproduction	2	2	2	3
3. Installation Common Services	12	256	39	40
Total, Management and Operations	34	279	62	65

Explanation of Fund Requirements

1. Administrative Communications	20	21	21	22

Included in this category are the costs of local telephone services for the Inspector General's office at NASA Headquarters.

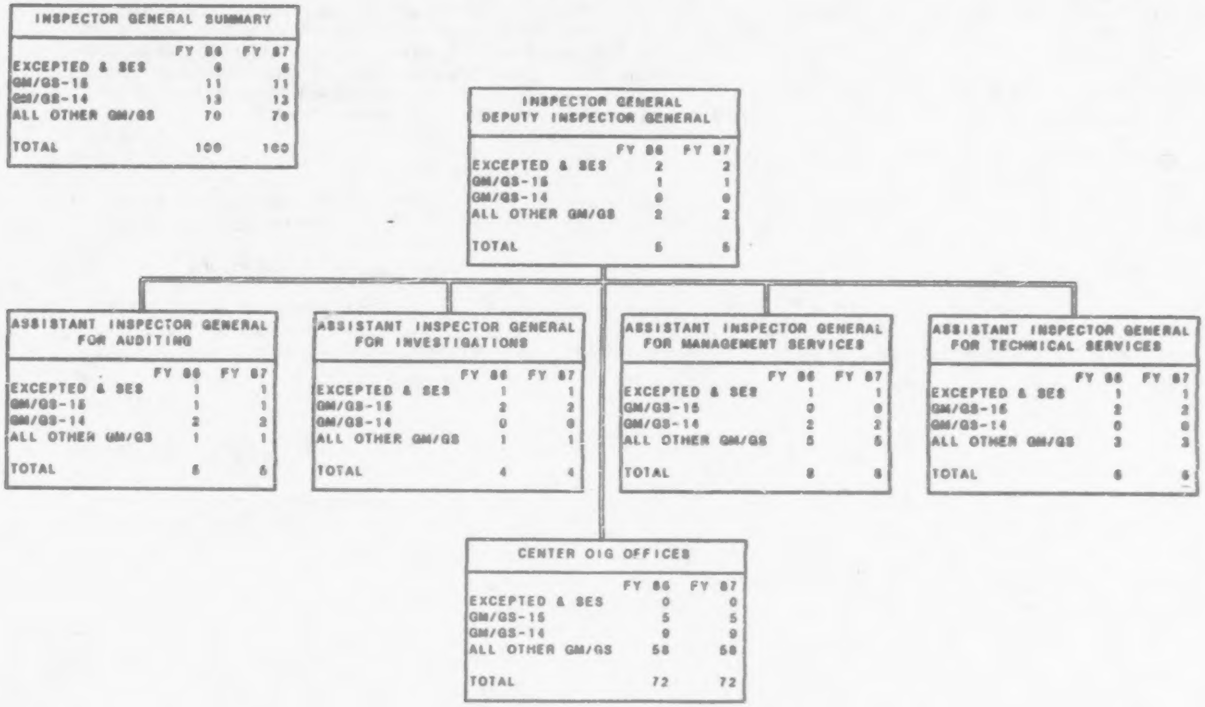
2. Printing and Reproduction	2	2	2	3

Costs of printing and reproduction services used by the Office of Inspector General at NASA Headquarters are included.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
3. Installation Common Services................	12	256	39	40

The Inspector General's direct use of administrative supplies, materials and equipment is covered in this subcategory. The decrease from the 1986 budget estimate reflects the transfer of funds originally budgeted here for automation activities to Technical Services.

ORGANIZATION AND STAFFING
OFFICE OF INSPECTOR GENERAL



INSPECTOR GENERAL SUMMARY

	FY 86	FY 87
EXCEPTED & SES	6	6
GM/GS-15	11	11
GM/GS-14	13	13
ALL OTHER GM/GS	70	70
TOTAL	100	100

INSPECTOR GENERAL
DEPUTY INSPECTOR GENERAL

	FY 86	FY 87
EXCEPTED & SES	2	2
GM/GS-15	1	1
GM/GS-14	0	0
ALL OTHER GM/GS	2	2
TOTAL	5	5

ASSISTANT INSPECTOR GENERAL FOR AUDITING

	FY 86	FY 87
EXCEPTED & SES	1	1
GM/GS-15	1	1
GM/GS-14	2	2
ALL OTHER GM/GS	1	1
TOTAL	5	5

ASSISTANT INSPECTOR GENERAL FOR INVESTIGATIONS

	FY 86	FY 87
EXCEPTED & SES	1	1
GM/GS-15	2	2
GM/GS-14	0	0
ALL OTHER GM/GS	1	1
TOTAL	4	4

ASSISTANT INSPECTOR GENERAL FOR MANAGEMENT SERVICES

	FY 86	FY 87
EXCEPTED & SES	1	1
GM/GS-15	0	0
GM/GS-14	2	2
ALL OTHER GM/GS	5	5
TOTAL	8	8

ASSISTANT INSPECTOR GENERAL FOR TECHNICAL SERVICES

	FY 86	FY 87
EXCEPTED & SES	1	1
GM/GS-15	2	2
GM/GS-14	0	0
ALL OTHER GM/GS	3	3
TOTAL	6	6

CENTER OIG OFFICES

	FY 86	FY 87
EXCEPTED & SES	0	0
GM/GS-15	5	5
GM/GS-14	9	9
ALL OTHER GM/GS	58	58
TOTAL	72	72

RESEARCH AND PROGRAM MANAGEMENT
FISCAL YEAR 1987 ESTIMATES

AGENCYWIDE ACTIVITIES

Summary of Resources Requirements (Thousands of Dollars)

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Facilities Services:				
Hazardous Substances Release Assessment	---	---	---	5,000
Technical Services:				
Automation Systems Development	---	---	---	7,500
Total	---	---	---	12,500

In the 1987 Budget Estimates NASA is requesting funds for two activities that are not specifically identified to individual centers: funds for environmental studies, and funds for developing automated administrative systems. The specific uses to which these funds will be put are as follows:

Hazardous Subatances Release Assessments:

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Hazardous Substances	---	---	---	1,400
Protection of Ground Water	---	---	---	3,600
Total	---	---	---	5,000

Over the past several years, court decisions, executive orders, and legislation have made it essential that NASA undertake a comprehensive evaluation of potentially hazardous environmental areas. The increasing number and complexity of environmental regulations affecting federal facilities have necessitated that NASA assess and analyse potential hazards from operations at its field installations. The diversity of these operations makes it necessary to investigate the contamination of air, water, and soil from an array of hazardous substances released at the field facilities. Because the areas to be assessed are complex, each potential problem must be fully recognized and understood before large sums of money are committed.

These funds will be apportioned to centers as appropriate to carry out specific studies and surveys.

	1987 Budget Estimate (Thousands of Dollars)
Hazardous Substances	1,400

Recent environmental laws have mandated the control of substances which are known to be hazardous, and have directed that research be conducted to identify hundreds of other substances which are toxic to human health. The minimization of generation of waste from these hazardous substances is required through conservation of resources and recovery practices. The application of best available technology in the pre-treatment of contaminated media is also prescribed by recent environmental laws. Each NASA installation will conduct studies and analyses of the composition of hazardous wastes generated, and develop the technology for pretreatment, recovery, and minimization of hazardous substances. Other hazardous substances requiring assessments include PCB's and asbestos. Studies required include inventory and identification, risk assessment, and sampling and analysis.

	1987 Budget Estimate (Thousands of Dollars)
Protection of Ground Water	3,600

Comprehensive Federal, state, and local laws require the protection and monitoring of ground water supplies. Studies will certify that present facilities (i.e., surface impoundments, underground storage tanks, etc.) preclude adverse impacts on ground water quality. Studies will also evaluate centers to investigate potential ground water contamination and to develop the method and extent of corrective effort where required.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Automated Systems Development:				
Development of Uniform Administrative ADP Systems	---	---	---	4,000
Essential Modification of Existing Administrative ADP Systems	---	---	---	2,000
Coordination and Control	---	---	---	1,500
Total	---	---	---	7,500

NASA, through the Automated Information Management (AIM) Program, will capitalize on the opportunities afforded by today's computer technology through the transition from existing installation unique automated administrative systems to agencywide Management Information Systems.

The AIM Program will enable NASA to meet many of its Information Resource Management responsibilities as required by the Paperwork Reduction Act of 1980 (Public Law 96-511). The AIM Program will also respond to the challenges and opportunities posed by the President's Reform 88 Program and the Grace Commission findings and recommendations that relate to expanded use of automated technologies to increase efficiency and reduce costs.

An Agency AIM Council was established in September 1984 to provide a way for the technology and expertise developed at a single NASA installation to be shared throughout the agency. This council is responsible for providing oversight for the coordination of AIM Program requirements and implementation across the agency.

An AIM Program plan has been developed which establishes the procedures, guidelines, and standards that will be used during the system development life cycle process for uniform agencywide administrative systems. This plan also establishes the AIM Program organization structure and responsibilities.

The AIM Program will consist of system development projects and other efforts to establish the institutional baseline capacity for uniform automated information management service throughout the Agency. The AIM Program will focus on those elements identified in the NASA Strategic AIM Plan as candidates for agencywide systems but will also consider other elements identified during the course of the program. Approval of AIM candidate systems will be based on the results of pre-definition studies, a non-advocate review process conducted by the AIM Council, and consultation among field installation and Headquarters management. The systems to be supported will be those with maximum potential for near term cost savings and increased efficiency.

	1987 Budget Estimate (Thousands of Dollars)
Development of Uniform Administrative ADP Systems................................	4,000

Reform 88 identified a number of areas where uniform/standard administrative ADP systems could be cost beneficial. NASA has undertaken studies to determine where NASA-wide administrative ADP systems should be developed. When the studies indicate that a single, uniform, decentralized system will result in significant savings and improve the delivery of the application services, the system development activity will be initiated at a lead center under the auspices of a Headquarters program manager.

1987
Budget
Estimate
(Thousands of Dollars)

Augmentation of Existing Administrative ADP Systems.............................. 2,000

These funds will be used to enhance or modify existing NASA-wide administrative ADP systems. Several NASA-wide systems require improvement: the Utility Control System (UCS), the Media Services Information System (MSIS) and Construction Management Information System. The basic hardware element of the UCS is obsolete and must be replaced. The MSIS workload has grown such that the original concept must be reviewed and a new system developed. Additional functions must be added to the Construction Management Information System necessitating a system redesign and new hardware. As these system augmentation projects are developed, they will come under the auspices of the AIM Program.

Coordination and Control.. 1,500

A key element of the AIM Program is the initial coordination and planning, and the mechanisms which control and manage the uniform systems in a decentralized organization like NASA. Strategic plans are necessary to provide for long term objectives so that appropriate system selection decisions can be made. Control is exercised through hardware and software configuration management processes. One upcoming area of planning and configuration management interest is communications. The NASA-wide administrative ADP systems of the future will be heavily dependent upon communications. Therefore, we must plan for and then control that communications environment.

RESEARCH AND PROGRAM MANAGEMENT

FISCAL YEAR 1987

JET PROPULSION LABORATORY

DESCRIPTION

The Jet Propulsion Laboratory (JPL) is located in Pasadena, California, approximately 20 miles north of downtown Los Angeles with subsidiary facilities located at Goldstone, California, (tracking and data acquisition), Edwards Air Force Base, California, (propellant formulation and testing), and Table Mountain, California (open air testing and astronomy).

At Pasadena, the Laboratory occupies 176 acres of land of which 156 acres are owned by NASA and 20 acres are leased. At Goldstone, facilities are located on land occupied under permit from the Army. At Edwards Air Force Base, facilities are located on land occupied under permit from the Air Force. The facilities at Table Mountain are located on land occupied under permit from the Forest Service of the Department of Agriculture. The capital investment of the Jet Propulsion Laboratory, including the Deep Space Network, fixed assets in progress, and contractor-held facilities, as of September 30, 1985, was $520,090,000.

The Jet Propulsion Laboratory is a Government-owned installation that is staffed and managed by the California Institute of Technology. Contract NAS7-918 between NASA and Caltech governs research, development, and related activities at the Laboratory with facilities being provided under a separate facilities contract NAS7-920(F). The cost of operating JPL for NASA activities is borne by the Research and Development and the Space Flight, Control and Data Communications appropriations, except for the lease or purchase of administrative aircraft and the purchase of passenger motor vehicles, which are funded from the Research and Program Management (R&PM) appropriation. Accordingly, the R&PM costs presented in this special analysis for JPL are for purposes of comparison only and are not a part of the NASA R&PM budget.

ROLES AND MISSIONS

In principal roles the Jet Propulsion Laboratory is responsible for the conduct of NASA automated missions concerned with scientific exploration of the solar system and deep space; for spacecraft tracking and data acquisition; for research and analysis required by deep space; and for the development of advanced spacecraft technologies including propulsion, guidance and control systems, electronics, and others. The Laboratory is also assigned responsibility for selected automated Earth-orbital projects and for the development and application of earth remote sensing technology and instruments. Implicit in these assignments is a broad range of engineering, scientific, and management functions devoted to:

1. The conduct of complete spaceflight projects, including overall project management and all phases of project activity beginning with mission design and following with spacecraft design, development, testing, flight operations, and data analysis.

2. The development and operation of the Deep Space Network (DSN) which provides tracking and data acquisition services for all NASA projects involving missions beyond near-Earth orbits.

3. Continuing programs of scientific investigation, and research and analysis.

In more specific terms, the principal Laboratory activities in support of NASA can be categorized as follows:

Solar System Exploration - Since the beginning of the Nation's space activities, JPL has devoted a major part of its efforts to exploration of the planets, their satellites, and the interplanetary medium. The Laboratory has had project management responsibility for all of the Mariner missions, including design, fabrication, assembly and testing of the spacecraft. During more than two decades, beginning with the Mariner 2 flight to Venus in 1962, these missions have produced enormous scientific returns. The two most recently completed missions in the Mariner series are those of Mariner 9, which returned scientific data for nearly a year from a Martian orbit, and Mariner 10, which gathered data in a close flyby of Venus followed by three separate encounters with Mercury.

The Jet Propulsion Laboratory was a major participant in the Viking project carrying out, among other assignments, the development of the two orbiters which, each carrying a lander, reached Mars during the summer of 1976. The Viking mission operations were repeatedly extended as the spacecraft far out-lived their design lifetimes. Operations were completed in 1983 when Viking Lander I, the last operating unit of the four, ceased functioning.

In the continuing series of planetary missions, JPL has management responsibility for the Voyager mission. The two Voyager spacecraft were launched in 1977 and made close flybys of Jupiter and its major satellites in 1979. In 1980 and 1981, the Voyager spacecraft encountered Saturn. Each of the four Voyager planetary encounters resulted in major scientific discoveries and obtained unique scientific data. Voyager 2 flew by Uranus in January 1986 and its trajectory will carry it on to arrive at the planet Neptune in 1989. Meanwhile, Voyager 1 continues to collect and transmit data on the interplanetary space environment as it proceeds out of the solar system.

The Laboratory also has project management responsibility for the Galileo mission, which is planned to orbit Jupiter and send an instrumented probe into the planet's atmosphere. The probe will make direct measurements of the physical and chemical properties of the Jovian atmosphere. During its in-orbit lifetime of 20 months, the orbiter will observe Jupiter and its system of satellites at close range. An option is available to provide an encounter with the asteroid amphritrite enroute to Jupiter. JPL is the management center for the Galileo project and is developing the orbiter in-house. The Ames Research Center is responsible for the probe development. The mission is scheduled for launch in May 1986.

The Ulysses Project is a cooperative effort between NASA and the European Space Agency (ESA) to study the sun at high solar latitudes. JPL is managing the development of the United States instruments which will fly on the ESA spacecraft, plus the corresponding data analysis. In addition, JPL is providing mission support to ESA. ESA is developing the spacecraft and a set of its own instruments. The launch is scheduled for May 1986.

The Magellan (formerly named Venus Radar) mission will obtain high resolution global radar imagery and altimetric and gravity data from a spacecraft orbiting Venus. The objectives are to address fundamental questions regarding the origin and evolution of the planet. The primary data gathering period will extend over one Venusian year equal to 243 earth days. JPL is managing the project, including responsibility for mission design and operations. Industry will develop the spacecraft and synthetic aperture radar under contract to JPL. The mission will be launched in 1988.

The Mars Observer mission will undertake planet-wide studies of the composition and physical state of Martian materials, examine the major surface forming processes and their time scales, and explore the structure and circulation aspects of the atmosphere. The Jet Propulsion Laboratory is the management center with responsibility for the scientific payload, and will contract with industry for development of the spacecraft bus. The mission will be launched in 1990.

Astrophysics - Consistent with its role as a center for Earth-orbital spacecraft development, JPL managed the Infrared Astronomical Satellite (IRAS) project, which was launched in January 1983. This was a cooperative mission with the Netherlands and the United Kingdom. The spacecraft, itself, was designed and built in the Netherlands. JPL was responsible for the infrared telescope development, system testing activities, and data analysis. Flight operations were completed in November 1983. IRAS has been a highly successful scientific undertaking, and the analysis of the enormous quantity of the data obtained will continue for many years.

JPL also managed an atmospheric science satellite, the Solar Mesosphere Explorer, which was launched on October 6, 1981, into a sun-synchronous polar orbit. The spacecraft module was developed under a JPL contract with private industry, and the five science instruments were developed by the Laboratory for Atmospheric and Space Physics at the University of Colorado.

Earth Science and Applications - In the area of space applications, JPL is a principal center for work in oceanographic applications of space technology. Development will be initiated on the Ocean Topography Experiment (TOPEX), a joint cooperative effort with the French, to develop and launch an ocean-observing satellite which will map the circulation of the Earth's oceans. JPL will have project management responsibility for the TOPEX, as well as responsibility for mission operations, and science data processing. The Laboratory also conducts significant activities in upper atmospheric research; in development and implementation of remote sensing techniques for Earth resources observations; and in geodynamics and plate tectonics research. Flight experiments for microgravity research in glasses and fluid behavior are also developed and carried out.

Spacecraft Flight Operations - The Jet Propulsion Laboratory is responsible for the design, development, maintenance, and operation of NASA's worldwide Deep Space Network (DSN) and a Mission Control and Computing Center. The DSN tracking stations are located in California, Spain, and Australia, and support projects involving flights beyond near-Earth orbit. The Mission Control and Computing Center is located at JPL, and is the location of actual day-to-day operations of deep-space missions. JPL is also implementing the Network Consolidation Program which co-locates major facilities of the Space Tracking and Data Network (STDN) near-Earth tracking stations with the three DSN stations. These consolidated facilities will be managed by JPL and will provide a more efficient, technically advanced, and cost effective means of operation.

Research and Analysis - The Jet Propulsion Laboratory maintains an effective program of advanced technical development to provide sound technologies for present and prospective project assignments and to further the general capabilities of NASA. Areas of involvement include spacecraft advanced development, autonomous systems, space power and propulsion systems, micro-electronics, information systems, and basic research in such fields as fluid physics, polymer materials, and applied mathematics. The Laboratory participates in scientific experiments on both JPL-managed and non-JPL-managed flight projects. This participation includes not only the performance of scientific investigations, but also a significant commitment to the development of scientific instruments for use in space missions. Ground-based research programs are carried out in the planetary sciences, physics and astronomy, Earth and ocean physics, and microgravity. These activities involve broad collaboration with the scientific and academic communities and with staff members from other NASA field installations.

SIMULATED RESEARCH AND PROGRAM MANAGEMENT BUDGET

FUNDING PLAN BY FUNCTION

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
I. Personnel and Related Costs	188,755	182,683	201,172	194,675
II. Travel	7,559	8,016	8,330	8,250
III. Operation of Installation	48,787	54,485	53,744	55,228
A. Facilities Services	(26,599)	(29,604)	(29,596)	(30,133)
B. Technical Services	(8,196)	(7,503)	(8,704)	(9,279)
C. Management and Operations	(13,992)	(17,378)	(15,444)	(15,816)
Total, Fund Requirements	245,101	245,184	263,246	258,153

EXPLANATION OF FUND REQUIREMENTS

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
I. PERSONNEL AND RELATED COSTS	**188,755**	**182,683**	**201,172**	**194,675**

The increase from the 1986 budget estimate to the 1986 current estimate is due to an increase in workforce and provides for the October 1, 1985 pay raise and anticipated higher costs of personnel benefits, such as health insurance and retirement costs and social security contributions. The decrease from the 1986 current estimate to the 1987 estimate is due to a projected decrease in workforce as applied to NASA funded work.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
II. TRAVEL	7,559	8,016	8,330	8,250

The increase from the 1986 budget estimate to the 1986 current estimate reflects a projected increase in workforce and increased travel costs as experienced in 1985.

III. OPERATION OF INSTALLATION	48,787	54,485	53,744	55,228
A. Facilities Services	26,599	29,604	29,596	30,133

The net increase from the 1986 current estimate to the 1987 estimate is due to anticipated higher utilities costs offset by reduced building lease costs due to the opening of the Central Engineering Building.

B. Technical Services	8,196	7,503	8,704	9,279

The increase from the 1986 budget estimate to the 1986 current estimate and the increase from the 1986 current estimate to the 1987 budget estimate is based on the 1985 experience.

C. Management and Operations	13,992	17,378	15,444	15,816

The decrease from the 1986 budget estimate to the 1986 current estimate is based on the 1985 experience.

DISTRIBUTION OF PERMANENT WORKYEARS BY PROGRAM

		1986		1987
	1985 Actual	Budget Estimate	Current Estimate	Budget Estimate
		(Thousands of Dollars)		
RESEARCH AND DEVELOPMENT	1,739	1,532	1,774	1,675
Space Station	39	---	32	35
Space Transportation Capability Development	5	26	8	8
Space Science and Applications	1,462	1,231	1,491	1,377
Physics and Astronomy	146	135	127	128
Life Sciences	15	17	23	25
Planetary Exploration	900	735	882	752
Space Applications	401	344	459	472
Commercial Programs	2	4	---	---
Technology Utilization	2	4	---	---
Commercial Use of Space	---	---	---	---
Aeronautics and Space Technology	157	189	161	173
Aeronautics	3	---	2	2
Space	154	189	159	171
Tracking and Data Advanced Systems	74	82	82	82
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS	406	408	393	344
Space Transportation Operations	10	7	14	12
Space and Ground Network, Communication and Data Systems	396	401	379	332
Subtotal, Direct Workyears	2,145	1,940	2,167	2,019
DIRECT SUPPORT	498	444	469	475
CENTER MANAGEMENT AND OPERATIONS	1,119	1,006	1,160	1,140
Total, Permanent Workyears	3,762	3,390	3,796	3,634

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1987 ESTIMATES

SUMMARY OF AIR TRANSPORTATION

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
		(Thousands of Dollars)		
Research and development	342,400	354,000	354,000	398,500
Construction of facilities	25,300	13,100	13,100	29,200
Research and program management	259,602	255,000	266,000	278,400
Total	627,302	622,100	633,100	706,100
Number of direct workyears associated with aeronautical research and technology	3,485	3,561	3,595	3,514

The objective of the aeronautical research and technology program is to conduct an effective and productive program that contributes materially to the enduring preeminence of U.S. civil and military aviation by: (1) conducting disciplinary and systems research at the leading edge of technology in those areas critical to the continued superiority of U.S. aircraft; (2) maintaining the research centers in positions of excellence in facilities and technical staff; (3) assuring timely transfer of research results to the U.S. aeronautical industry; (4) assuring appropriate involvement of universities and industry; and (5) providing aeronautical development support to other government agencies and U.S. industry. Additional emphasis has been given to emerging technologies with potential for order-of-magnitude advances in capability or performance. The far-term focus of the program provides results well in advance of specific applications and provides long-term, independent research and technology which is not driven by the development and operational pressures often encountered by the Department of Defense (DOD) and industry. Both fundamental research in the aeronautical disciplines and systems research directed at interaction among disciplines, components, and subsystems applicable to general classes of advanced aircraft are included. The program involves participation by aeronautical manufacturers from the industrial base to ensure that the technology is compatible with practical design considerations and to effect a rapid transfer into superior military and civil aricraft.

The 1987 estimate is based on an increased effort to aggressively pursue the highest payoff technologies with potential for order-of-magnitude advances in capability or performance. A unique opportunity in high-speed flight is focusing substantially increased emphasis in generic hypersonic technologies supporting the aerospace plane program. Subsonic transport and rotorcraft needs are addressed primarily through fundamental research aimed at the critical technology areas. Key high-performance aircraft technology efforts are accelerated, and a small effort in supersonic cruise technology is being maintained. The estimate also reflects the need to continue important efforts in the fundamental aeronautical disciplines and systems research and to support specialized facilities essential to aeronautics research.

The base research and technology program includes generic research which is broadly applicable to all classes of aircraft (general aviation/computer, transport, rotorcraft, supersonic cruise, fighter/attack, and hypersonic) and focused research which is specific to one class of aircraft. Systems technology programs are more focused in applications and/or have the characteristics of specific projects, i.e., advanced turboprop, X-wing, and oblique wing. Funding for the technical operations of wind tunnels, propulsion facilities, computational facilities, simulators, and flight research operations is covered in the most appropriate discipline elements of the research and technology base. In 1987 research and technology base funding will support the operating cost for the numerical aerodynamic simulation (NAS) program, and systems technology funding covers the final NASA commitment to the X-wing program. A brief summary of some of the major thrusts for both the research and technology base and systems technology programs follows.

In fluid and thermal physics research, strong emphasis will continue on three-dimensional computational fluid dynamics (CFD) methods that will increase the speed and efficiency of flow solvers by two orders of magnitude and on novel techniques and devices to reduce aircraft drag by up to 60 percent. Benchmark experiments for CFD code validation and turbulence modeling will be strengthened.

Applied aerodynamics research efforts in high angle-of-attack aerodynamics will include wind tunnel and flight evaluations to improve the understanding of performance in both the low- and high-speed flight regimes and to correlate with predictions. Research efforts in test techniques will address laser holigraphics and nonintrusive measurement techniques which will provide an order-of-magnitude improvement in test accuracy.

In propulsion and power research, continued attention will be given to the technologies for small engines which will enable up to 50-percent improvement in fuel efficiency. Internal computational fluid mechanics efforts will address the physical modeling of complex internal flows and the validation of codes as part of the goal to reduce calculation times by an order of magnitude. Supersonic combustion ramjet (scramjet) and combined cycle engine research will be strengthened to address the technologies critical to the flight of high-speed vehicles from takeoff to orbital speeds.

Materials and structures research will increase in the area of composite materials, which can provide up to a 50 percent weight savings for future aircraft. Initial efforts will focus on thermoplastics and ceramic-matrix composite materials, as well as structural concepts exploiting their anisotropic properties. Research emphasis will also be increased in high-temperature materials and structures and thermal-barrier coatings with high-erosion resistance. A focused effort will be initiated in rotorcraft airloads to correlate noise and vibration predictions as part of the goal to reduce noise and vibration by 80 percent.

Information science research will continue to focus on flight-crucial software and concurrent processing to provide an order-of-magnitude improvement of efficiency and reliability. Controls and guidance and human factors research will focus on the application of artificial intelligence technology to enhance the operations of future aircraft. Increased emphasis will be placed on controls research for highly maneuverable aircraft. Human factors research will continue to address the critical man-machine interface issues which affect the safety and operational limitations of aircraft.

Flight systems research will provide focus on highly maneuverable aircraft capable of high angle-of-attack operation at low speeds, high-speed manueverability, and short takeoff and vertical landing. Analytical and experimental investigations will be conducted on thrust-vectoring concepts to enhance high angle-of-attack maneuverability. Supersonic vertical/short takeoff and landing (V/STOL) concepts will be studied as the initial part of a joint United States/United Kingdom program. Other studies, conducted as part of the systems analysis effort, will determine the overall benefit of synergistic integration of component and subsystem technologies for hypersonic aircraft applications.

Rotorcraft systems technology efforts will include publication of an external noise prediction methodology aiming toward a three order-of-magnitude increase in accuracy and wind tunnel testing of an advanced, bearingless rotor. Activities in technology for next-generation rotorcraft with more than a twofold increase in speed will be focused on completion of flight testing of the X-wing rotor system on the rotor systems research aircraft to include conversion from rotorary to stopped-rotor flight mode.

Areas of continued emphasis in high-performance aircraft research are high angle of attack, with initial testing up to 20 degrees, integrated propulsion/flight controls to allow 10-15 percent performance improvements, supermaneuverability, short takeoff and vertical landing technology, and forward swept wing technology. The oblique wing technology program, being conducted jointly with the Navy to exploit the potential for high performance at subsonic and supersonic speeds, will include the detailed design and fabrication of the oblique wing and associated modifications of the NASA F-8 aircraft. Flight test is planned to begin in 1989. Ceramic and ceramic-matrix research for turbine engines with operating temperatures up to 2300 degrees Fahrenheit will continue, along with the development of the analysis tools to accurately predict the life and assess the durability of turbine engine hot section components.

In the advanced turboprop program aimed at a 30 percent reduction in transport fuel consumption, flight testing of the large-scale single-rotation propeller to build a performance data base for high-speed propeller aerodynamics and structures will be conducted. Geared counter-rotation propeller model tests will also be conducted. The general aviation/commuter engine research will include the definition of reference engines to focus and drive component technology development to large-engine performance levels and to provide a quantitative measure of the performance impact of advances as they are made.

In the NAS program, the initial operating configuration and the second high-speed processor for the extended operating configuration, allowing four to six times more computing power, will be installed in the new NAS facility. All subsystem upgrades will reach full capability early in 1989.

NASA, in conjunction with the Department of Defense, is developing the technology base for a potential national aerospace plane. The objective of the NASA transatmospheric research and technology program is to accelerate the development of the critical enabling technologies for a potential revolutionary new class of hypersonic/transatmospheric vehicles in the future. Such vehicles could be capable of horizontally taking off from and landing on conventional runways, using airbreathing propulsion up to, or near, orbital speed, and providing rapid and low-cost access to space.

The research and program management funding in 1987 provides for the salaries and travel of 3,514 direct civil service workyears, for the utilities necessary to conduct wind tunnel operations, and for other general operation of installation costs necessary to conduct the NASA aeronautics program.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RESEARCH AND DEVELOPMENT

ESTIMATED 1987 OBLIGATIONS FOR EQUIPMENT TO BE PLACED AT NASA INSTALLATIONS

Program Budget Line Item	1987 Estimate (Thousand of Dollars)
Research and Development	164,953
Space Transportation Capability Development	(55,000)
Space Station	(43,600)
Physics and Astronomy	(1,369)
Planetary Exploration	(10,080)
Life Sciences	(843)
Space Applications	(7,781)
Aeronautical Research and Technology	(38,236)
Space Research and Technology	(7,833)
Space Flight, Control and Data Communications	114,887
Shuttle Production and Capability Development	(55,333)
Space Transportation Operations	(44,184)
Space and Ground Networks, Communication and Data Systems	(15,300)
GRAND TOTAL	279,840

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATIONS, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Transportation Capability Development	Johnson Space Center, Location 7201-xx, 87-002615	Center Info. Network Hardware	Supports Data System & Flight Operation.	$1,300
Space Transportation Capability Development	Johnson Space Center, Location 7201-xx, 87-002620	IBM Peripherals Reconfiguration	Supports Data System & Flight Operation.	$ 734
Space Transportation Capability Development	Johnson Space Center, Location 7201-xx, 87-002630	Purchase Sperry Peripherals	Supports Data System & Flight Operation.	$ 200
Space Transportation Capability Development	Johnson Space Center, Location 7201-xx, 87-002635	Replacement FR80 Microfilm	Supports Data System & Flight Operation.	$ 450
Space Transportation Capability Development	Johnson Space Center, Location 7201-xx, 87-003100	Center Info. Sys. IBM 3083	Supports Data System & Flight Operation.	$2,512
Space Transportation Capability Development	Johnson Space Center, Location 7201-xx, 87-003105	Central Computing Fac. Peripherals	Supports Data System & Flight Operation.	$ 324
Space Transportation Capability Development	Johnson Space Center, Location 7201-xx, 87-003110	Sperry Equipment Lease	Supports Data System & Flight Operation.	$2,207
Space Transportation Capability Development	Johnson Space Center, Location 7210-xx, 87-002720	Flight Data System Upgrade	Supports Research & Test Operations.	$ 245
Space Transportation Capability Development	Johnson Space Center, Location 7222-xx, 87-002735	Thermal Synth. Sys.	Supports Research & Test Operations.	$1,800
Space Transportation Capability Development	Johnson Space Center, Location 7234-xx, 87-002755	Crew Sys. Div. Sys. Replacement	Supports Research & Test Operations.	$ 575
Space Transportation Capability Development	Johnson Space Center, Location 7234-xx, 87-002760	Data Acquisition Retrieval Sys Enchancement	Supports Research & Test Operations.	$ 360

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Transportation Capability Development	Johnson Space Center, Location 7238-xx, 87-002770	Artificial Intelligence System	Supports Research & Test Operations.	$ 300
Space Transportation Capability Development	Johnson Space Center, Location 7244-xx, 87-002805	Network/VAX Upgrades	Supports Research & Test Operations.	$ 338
Space Transportation Capability Development	Johnson Space Center, Location 7258-xx, 87-002833	Shuttle Engineering Simulation ADPE Upgrade	Supports Research & Test Operations.	$3,600
Space Transportation Capability Development	Johnson Space Center, Location 7238-xx, 87-002843	CAD Workstations	Supports Research & Test Operations.	$ 730
Space Transportation Capability Development	Johnson Space Center, Location 7258-xx, 87-002850	LMI LISP Machine Inc. Upgrades	Supports Research & Test Operations.	$ 262
Space Transportation Capability Development	Johnson Space Center, Location 7256-xx, 87-003170	ADPE Lease	Supports Research & Test Operations.	$ 962
Space Transportation Capability Development	Johnson Space Center, Location 7258-xx, 87-002860	Artificial Intelligence Systems	Supports Research & Test Support.	$ 302
Space Transportation Capability Development	Johnson Space Center, Location 7262-xx, 87-002883	User Workstations Network Augmentation	Supports Research & Test Operations.	$ 500
Space Transportation Capability Development	Johnson Space Center, Location 7263-xx, 87-002820	VAX 11/750 Upgrade	Supports Research & Test Operations.	$ 300
Space Transportation Capability Development	Johnson Space Center, Location 7265-xx, 87-002800	Engineering UWS Replacements	Supports Research & Test Operations.	$ 350

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Transportation Capability Development	Johnson Space Center, Location 7274-xx, 87-002950	Artificial Intel. Lab Purchase	Supports Data System & Flight Operation.	$ 200
Space Transportation Capability Development	Kennedy Space Center, Location 7601-P3, 87-001435	CAE Amendment 3	Supports Launch Systems Operations.	$ 300
Space Transportation Capability Development	Kennedy Space Center, Location 7601-P7, 87-001430	Interactive Graph System	Supports Launch Systems Operations.	$ 200
Space Transportation Capability Development	Kennedy Space Center, Location 7601-S4, 87-001485	Space Station Mission Assement	Supports Launch Systems Operations.	$ 180
Space Transportation Capability Development	Kennedy Space Center, Location 7601-01, 87-001445	Microcomputers, Mini-computers and peripherals	Supports Spacelab Operations.	$ 800
Space Transportation Capability Development	Marshall Space Flight Center, Location 6201-01, 87-001935	Engineering Analysis & Data System	Supports Research & Test Operations.	$12,000
Space Transportation Capability Development	Marshall Space Flight Center, Location 6201-26, 87-002035	IBM 4341 Central Processing Unit Augmentation	Supports Research & Test Operations.	$ 288
Space Transportation Capability Development	Marshall Space Flight Center, Location 6206-CU, 87-002285	Interactive Graphics Design Sys Modif Bldg 4487	Supports Research & Test Operations.	$ 101

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 87 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Station	NASA Headquarters, Location 100-00, 87-010120	Headquarters Tech Mgt Info Sys (TMIS)	Supports Program Management/Integration	$ 617
Space Station	Langley Research Center, Location 2303-DC, 87-009025	ADP Hardware Purchase	Supports Program Management/Integration	$ 400
Space Station	Marshall Space Flight Center, Location 4201-39, 87-002090	Continued Lease of Space Station IBM 4381	Supports Program Management/Integration	$ 400
Space Station	Johnson Space Center, Location 7210-xx, 87-002685	Flight Data System Upgrade	Supports Utilization	$ 350
Space Station	Johnson Space Center, Location 7210-xx, 87-002690	Purchase VAX Mini Computer or Equivalent	Supports Utilization	$ 250
Space Station	Johnson Space Center, Location 7210-xx, 87-002695	Purchase VAX 8600 Computer or Equivalent	Supports Utilization	$ 400
Space Station	Johnson Space Center, Location 7210-xx, 87-002700	CSTAR (Space Attitude Control Program)	Supports Advanced Development	$ 150
Space Station	Johnson Space Center, Location 7210-xx, 87-002705	Flight Control Optics Lab	Supports Advanced Development	$ 385
Space Station	Johnson Space Center, Location 7210-xx, 87-002710	Guidance Navigation Control	Supports Advanced Development	$ 370
Space Station	Johnson Space Center, Location 7228-xx, 87-002740	Symbolics 3640-4 Pak	Supports Program Management/Integration	$ 18
Space Station	Johnson Space Center, Location 7244-xx, 87-002765	Space Station Cad Support	Supports Program Management/Integration	$ 300

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Station	Johnson Space Center Location 7283-xx, 87-003060	Tech Mgt & Info Sys (TMIS) Phase C/D Purchase	Supports Program Management/Integration	$26,000
Space Station	Johnson Space Center Location 7283-xx, 87-003070	On Board Computer & Sim. Interfaces	Supports Advanced Development	$ 750
Space Station	Johnson Space Center, Location 7285-xx, 87-003100	Software Support Environment Test Bed	Supports Advanced Development	$ 773
Space Station	Johnson Space Center, Location 7285-xx, 87-003105	Software Support Environment Mainframe	Supports Program Management/Integration	$ 6,621
Space Station	Johnson Space Center, Bldg. 30, 72-87-06	Space Station Info Sys Configuration & Ops. Support	Provide Hardware for SSIS Operations & Analysis	$ 150
Space Station	Johnson Space Center, Bldg. 30, 72-87-07	Space Station Info Sys Definition Support	Provide Interface to Remote Operation Test Bed Facilities	$ 180
Space Station	Kennedy Space Center, Location 7602-00, 87-001265	Computer Aided Dev/ Computer Aided Eng-Definition	Supports Program Management/Integration	$ 3,008
Space Station	Kennedy Space Center, Location 7602-00, 87-001250	Logistics Management Info Sys - Definition	Supports Operational Readiness	$ 347
Space Station	Kennedy Space Center, Location 7602-00, 87-008965	Computer Aided Inter-face Verif-Definition	Supports Program Management/Integration	$ 300
Space Station	Kennedy Space Center, Location 7602-0 ,87-001280	OOMS Definition Ground Data Mgt Sys	Supports Operational Readiness	$ 2,311
Space Station	Kennedy Space Center, Location 7603-51, 87-001260	Space Station Operational Language Sys	Supports Focused Technology	$ 200

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Physics and Astronomy	Ames Research Center, Location 21VO-74, 87-006580	Adams System Replacement	Supports Airborne Research	$ 110
Physics and Astronomy	Jet Propulsion Laboratory, Location 5507-IP, 87-000685	Not Select; Host Comp Sys Infared Astron. Satellite Proj.	Supports Astrophysics Mission Operations & DA	$ 280
Physics and Astronomy	Marshall Space Flight Center, Location 6209-TC, 87-002390	Payld Crew Training Compl Devel & Oper Proc Sys Re	Supports Spacelab Mission Mgt--Approved Missn	$ 400
Planetary Exploration	Jet Propulsion Laboratory, Location 5503-MS, 87-000648	Microcomputers, Mini-Computers and Peripherals	Supports Flight Mission Operations & Data Analysis	$ 9,444
Planetary Exploration	Jet Propulsion Laboratory, Location 5508-IO, 87-000635	3 Computervision Systems for Computer-Aided Design	Supports Mission Operations & Data Analysis	$ 146

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Applications	Goddard Space Flight Center, Location 5101-AA, 87-009135	Science Computing Facility	Supports Data Systems	$ 531
Space Applications	Goddard Space Flight Center, Location 5101-AB, 87-009205	National Space Science Data Center	Supports Data Systems and Dynamics	$ 130
Space Applications	Goddard Space Flight Center, Location 5101-AM, 87-009325	Vector Processing Facility	Supports Data Systems and Oceanic Processes	$ 816
Space Applications	Goddard Space Flight Center, Location 5101-AM, 87-009360	Vector Processing Facility NAS 5-28646 (CDC)	Supports Data Systems	$ 884
Space Applications	Goddard Space Flight Center, Location 5101-AM, 87-009365	Vector Processing Facility NAS 5-28646 (CDC)	Supports Data Systems	$ 500
Space Applications	Goddard Space Flight Center, Location 5103-BE, 87-009520	Applications Processing	Supports Resource Observation Applied Res. and Roentgen Satellite	$ 338
Space Applications	Goddard Space Flight Center, Space and Applications Computing Center (SACC), 51-81-01	SACC Upgrade	Continues multi-year replacements of current computing facility to meet OSSA program requirements.	$ 1,538
Space Applications	Goddard Space Flight Center, Building 28, 51-82-10	High Speed Computing Facility	Supplements and extends capability of existing Amdahl 470V/6 used in atmospheric sounding retrieval, data assembly, atmospheric modeling, numerical forecast development ment in support of Global Atmospheric Research Program (GARP) and NASA Climate Research Program.	$ 3,081

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Aeronautical Research & Technology	Ames Research Center, NAS Facility 21-86-03	Numerical Aerodynamic Simulation Processing System Network (NPSN)	Provides a large scale, high performance computational resource for solving three dimensional, viscous fluid flow equations specifically oriented toward the solution of aerodynamic and fluid dynamic problems	$19,300
Aeronautical Research & Technology	Ames Research Center, Bldg 233, Central Computer, Facility 21-85-01	Large Scale Scientific Processor (LSSP)	Provides large scale, very high-speed vector processing capabilities in computational fluid dynamics and computational physics	$ 2,956
Aeronautical Research & Technology	Ames Research Center, Bldg N-233, 21-87-02	Central Storage System	Provides for increased data storage and data management facilities for the Central Computer Facility computers	$ 638
Aeronautical Research & Technology	Ames Research Center, Bldg N-211, 21-88-04	B-200 Super King Air Aircraft	Provides inflight monitoring of research aircraft operations and related logistics support for research programs	$ 888
Aeronautical Research & Technology	Ames Research Center, Bldg N-233, 21-87-03	Convex Computer System	Provides Cray computer compatibility by emulating Cray instruction set, enabling codes developed on a Cray to be run on this computer at a slower speed	$ 1,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Aeronautical Research & Technology	Ames Research Center, Bldg N-243, 21-87-04	Simulation Computer System Replacement	Upgrade simulation computational capabilities to support ongoing and future programs, replacing obsolete equipment	$ 800
Aeronautical Research & Technology	Ames Research Center, Bldg N-233, 21-87-05	Layered, Interactive Front-End Computer System	Integrates scientific programming environment provided by the Central Computer Facility, providing processing support for work stations, interactive pass-through to supercomputers, and other interactive capabilities	$ 682
Aeronautical Research & Technology	Ames Research Center, Bldg N-257, 21-87-06	Aircraft System Modeling and Control/ Advanced Concepts Simulator	Replaces aircraft systems modeling control computer used to drive the advanced concepts flight simulator, to provide increased capacity and response time to pilot inputs and simulated external events for better simulation of a real-time flight environment	$ 500
Aeronautical Research & Technology	Langley Research Center, Bldg 1268, 23-87-01	Computer-aided Design/ Engineering Capability for Electronic Systems	Provides for electronic design/instrumentation in support of over 30 projects in aircraft flight, spaceflight, and aerodynamic research	$ 342
Aeronautical Research & Technology	Langley Research Center, Location 2302-BB, 87-008790, 23-87-02	Mid-range Computers	Upgrades 6 mid-range processors to replace obsolete equipment and to provide a modest improvement in computing power	$ 982

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/FAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Aeronautical Research & Technology	Langley Research Center, Location 2304-C1, 87-008870, 23-87-03	7X10-ft. High-Speed Tunnel Data System	Upgrades current system to support research demands	$ 168
Aeronautical Research & Technology	Langley Research Center, Location 2304-C4, 87-008940, 23-87-04	Avionics Integration Research Laboratory	Upgrades existing system to provide additional storage capacity	$ 400
Aeronautical Research & Technology	Langley Research Center, Bldg 1230, 23-87-05	Instrument Research Division Data Systems Laboratory	Upgrades system to support installed systems and development of new capabilities	$ 118
Aeronautical Research & Technology	Langley Research Center, Location 2302-BB, 87-003785, 23-87-06	Supercomputer Augmentation	Augments capability through acquisition and integration of new supercomputer to support research requirements in such areas as computational fluid dynamics, structures, and materials	$ 2,311
Aeronautical Research & Technology	Langley Research Center, Bldg 1268, 23-87-07	Minicomputer Host System for Aerothermal Loads Complex	Provides for a local computer system to interface with data acquisition systems of various research and wind tunnel facilities to enable more rapid data analysis	$ 278
Aeronautical Research & Technology	Langley Research Center, Location 2302-BB, 86-008055	Simulation Network	Options for completion of the real time communication subsystem	$ 318
Aeronautical Research & Technology	Langley Research Center, Location 2302-BB, 86-008070	Vector Processing	Upgrades vector system to 32 million 64-bit words of high-speed control memory	$ 1,026

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Aeronautical Research & Technology	Langley Research Center, Location 2304-C3, 87-008825	8-Foot High Temperature Structures Tunnel (HTST) Data Systems Upgrade	Upgrades current system to support research demands	$ 335
Aeronautical Research & Technology	Langley Research Center, Location 2302-BB, 87-008750	Mass Storage	Adds additional cartridge storage units to meet increased volume	$ 120
Aeronautical Research & Technology	Langley Research Center, Location 2304-C1, 87-008860, 23-87-08	Unitary Plan Wind Tunnel Data System Upgrade	Upgrades current system to support research demands	$ 67
Aeronautical Research & Technology	Langley Research Center, Bldg 1192, 23-87-09	Computational Fluid Dynamics (CFD) Super Minicomputer	Provides for CFD code development and pre/post processing of large CFD application programs executed by VPS-32 supercomputer	$ 425
Aeronautical Research & Technology	Langley Research Center, Location 2304-C9, 87-00893, 23-87-10	Structures Research Laboratory Data System	Replacement of current system to provide expanded capabilities to meet research demands	$ 250
Aeronautical Research & Technology	Langley Research Center, Bldg 1268, 23-87-11	Technology for Integrated Problem Solving Laboratory	Upgrades VAX-780 and provides for workstations and graphics capability to equip a multidisciplinary research laboratory	$ 184
Aeronautical Research & Technology	Lewis Research Center, Location 220R-TS, 87-000350, 22-65-01	Real-Time Simulation System	Provides real-time simulation of propulsion systems	$ 1,200
Aeronautical Research & Technology	Lewis Research Center, Location 220S-MS, 87-000310, 22-87-02	Shared Mass Storage Hardware	Provides an archival medium for long-term storage of data with low frequency of access	$ 125

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Aeronautical Research & Technology	Lewis Research Center, Bldg 142, 22-87-02	Front-End Processor Hardware	Upgrades and augments capability to manage and provide access to mainframe computers	$ 250
Aeronautical Research & Technology	Lewis Research Center, Location 2200-PT, 87-000350, 22-87-03	Program Support Communications Network (PSCN) and Time Div. Multiple Access Hardware	Provides gateway interface hardware interconnection between central processors and the PSCN	$ 175

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Research & Technolgy	Langley Research Center, Bldg. 1230, 23-67-12	Nondestructive Evaluation (NDE) Laboratory	Provides for various pieces of equip. and systems to be installed in a new laboratory to improve capability to achieve next generation programs and to develop real accept/reject criteria for aerospace components.	$ 820

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7203-00, 87-002655	Mission Control Center	Supports Launch and Mission Support	$ 4,288
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7208-xx, 87-002665	Shuttle Reconfig. Sys./ Auto	Supports Orbiter	$ 686
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7208-xx, 87-002680	Voice System Computer	Supports Launch and Mission Support	$ 315
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7208-xx, 87-003150	Shuttle Mission Simulator Host Disk A/B/C	Supports Orbiter	$ 407
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7208-xx, 87-003155	Shuttle Mission Simulator 8480 Disk	Supports Orbiter	$ 286
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7208-xx, 87-003180	Lease Sperry 1191 Equipment	Supports Orbiter	$ 2,611
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7210-xx, 87-002713	Inertial Sys. Lab	Supports Orbiter	$ 210
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7238-xx, 87-002615	Shuttle Engineering Simulator Augmentation	Supports Orbiter	$ 145

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7277-xx, 87-002995	Software Development Facility System	Supports Orbiter	$ 2,500
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7277-xx, 87-003000	Flight EO. Interface Device	Supports Orbiter	$ 300
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7277-xx, 87-003005	Flight EO. Interface Device 8 Upgrade	Supports Orbiter	$ 350
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7277-xx, 87-003015	Reconfiguration Network Expansion	Supports Orbiter	$ 250
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7277-xx, 87-003020	Software Production Facility Peripherals	Supports Orbiter	$ 50
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7277-xx, 87-003025	4381 Software Development Facility Upgrade	Supports Orbiter	$ 500
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7277-xx, 87-003030	Controllers	Supports Orbiter	$ 150
Space Shuttle Production and Capability Development	Johnson Space Center, Location 7277-xx, 87-003235	Upgrade IBM 3081 to 3084 Q	Supports Orbiter	$ 2,183
Space Shuttle Production and Capability Development	Johnson Space Center, Bldg. 30, 72-87-08	Reliability Replacement	Supports Orbiter	$ 3,483

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Shuttle Production and Capability Development	Kennedy Space Center, Location 7602-00, 87-001230	Central Data Subsystem	Supports Launch Site Equipment	$ 3,000
Space Shuttle Production and Capability Development	Kennedy Space Center, Location 7602-00, 87-001325	Checkout Controls & Mon. Subsystem II Hardware Upgrades	Supports Launch Site Equipment	$ 2,000
Space Shuttle Production and Capability Development	Marshall Space Flight Center, Location 4206-DB, 87-002280	AD10 Floating Point Expansion for HDMR Simul Lab	Supports Space Shuttle Main Engine (SSME)	$ 350

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Transportation Operations	Ames Research Center, Dryden Flight Research 21-87-01	Aerial Work Platforms	Supports Shuttle	$ 450
Space Transportation Operations	Johnson Space Center, Location 7201-xx, 87-003080	Sperry Equipment Lease	Supports Flight Operations	$ 881
Space Transportation Operations	Johnson Space Center, Location 7201-xx, 87-003115	Data Comm. Lines	Supports Flight Operations, and Program Management/Integration	$ 213
Space Transportation Operations	Johnson Space Center, Location 7201-xx, 87-003120	Sperry Equipment Lease	Supports Flight Operations, and Program Management/Integration	$ 221
Space Transportation Operations	Johnson Space Center, Location 7203-xx, 87-003145	Mission Control Center ADPE	Supports Flight Operations	$ 151
Space Transportation Operations	Johnson Space Center, Location 7266-xx, 87-002938	MIDAS System	Supports Flight Operations	$ 420
Space Transportation Operations	Johnson Space Center, Location 7266-xx, 87 002945	XEROX Star Upgrade	Supports Flight Operations	$ 228
Space Transportation Operations	Johnson Space Center, Location Bldg. 11&30, 72-87-01	Software Production Facility (SPF)	Completes Upgrade to the SPF	$ 4,188
Space Transportation Operations	Johnson Space Center, Various Locations, 72-87-05	Center Communications System	Upgrade and Replace Existing Telecommunications System	$ 4,800
Space Transportation Operations	Johnson Space Center, Location Bldg. 30, 72-87-03	Calibrated Ancillary System	Extracting Ancillary Data from the Orbiter Down Link, Calibrating the Data and Sending Processed Data to the OSFC	$ 66

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Transportation Operations	Johnson Space Center, Location STSOC Facility, 72-87-04	Automated Test Equip.	Improve the Availability of the SMS and MCC for Flight Crew Training and Mission Support	$ 1,400
Space Transportation Operations	Kennedy Space Center, Location 7801-01, 87-001350	Microcomuplers, mini-computers and peripherals	Supports Launch and Landing Operations	$ 1,782
Space Transportation Operations	Kennedy Space Center, Location 7802-00, 87-001370	Kennedy Data Mgt. Sys. Allocation	Supports Launch and Landing Operations	$ 375
Space Transportation Operations	Kennedy Space Center, Location Complex 40, 76-87-01	Recharger	Supports Shuttle Operations	$ 375
Space Transportation Operations	Kennedy Space Center, Shuttle Landing Facility 76-87-02	Aircraft Fueler Tank Truck	Supports Shuttle Operations	$ 350
Space Transportation Operations	Kennedy Space Center, CIF, 76-87-03	Automated Test Equipment (ATE)	Supports Shuttle Operations	$ 1,200
Space Transportation Operations	Kennedy Space Center, Location K6-1996B Operation Shop, 76-87-04	Mobile Work Platform, Diesel Engine	Supports Shuttle Operations	$ 299
Space Transportation Operations	Kennedy Space Center, Location K6-1996B Operations Shop, 76-87-05	Crane 65-ton	Supports Shuttle Operations	$ 365
Space Transportation Operations	Kennedy Space Center, Location K6-1996B Operations Shop, 76-87-06	Crane, Mobile 200-ton	Supports Shuttle Operations for the Shuttle Processing Contract	$ 1,300
Space Transportation Operations	Marshall Space Flight Center, Location 4200-00, 87-002165	Uniservo Subsystem Replacement	Supports Flight Hardware	$ 833

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/EAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space Transportation Operations	Marshall Space Flight Center, Location 6200-00, 87-002170	Sperry 1100/82	Supports Flight Hardware	$ 834
Space Transportation Operations	Marshall Space Flight Center, Location 6200-00, 87-002175	Interscience Syst. Inc., Disk Subsyst Replacement	Supports Flight Hardware	$ 102
Space Transportation Operations	Marshall Space Fli[illegible] Center, Location [illegible] 25, 87-001875	[illegible]n Lease of 1.5 [illegible]BYTS MEM & THRD SPERRY 1100 Pro	Supports Flight Hardware, and Spacelab Operations	$ 309
Space Transportation Operations	Marshall Space Flight Center, Location 6201-25, 87-001880	Continued Lease of High Capacity Mass Storage	Supports Flight Hardware	$ 573
Space Transportation Operations	Marshall Space Flight Center, Location 6208-46, 87-002370	Upgrade VAX 8800 for Materials Data Base	Supports Solid Rocket Boosters, and Flight Hardware	$ 250

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY OF MAJOR EQUIPMENT ACQUISITION OBLIGATIONS INCLUDED IN 1987 BUDGET

PROGRAM BUDGET LINE ITEM	RECEIVING INSTALLATION BUILDING LOCATION, AND ADP/FAD CONTROL NUMBER	EQUIPMENT DESCRIPTION	PROGRAMMATIC PURPOSE	ESTIMATED 1987 OBLIGATIONS ($ IN THOUSANDS)
Space and Ground Networks, Communication and Data Systems	Ames Research Center Dryden Flight Research Facility, Crows Landing Site, 21-87-07	Telemetry/Tracking System, multi-frequency tracker to replace single axis system	Supports flight missions at the Western aeronautical test range	$ 900
Space and Ground Networks, Communication and Data Systems	Ames Research Center Dryden Flight Research Facility, 21-87-08	Data Processing System Upgrade	Supports flight missions at the Western aeronautical test range	$ 1,800
Space and Ground Networks, Communication and Data Systems	Goddard Space Flight Center, Bldg. 14, 51-80-02	Project Operations Control Center	Supports mission control workload	$ 1,000
Space and Ground Networks, Communication and Data Systems	Goddard Space Flight Center, Bldg. 14, 51-80-04	Hubble Space Telescope Operations Control Center	Real-time operation of Hubble Space Telescope spacecraft	$ 300
Space and Ground Networks, Communication and Data Systems	Goddard Space Flight Center, Bldg. 23, 51-82-04	Univac 1100/82 Computer and Peripherals	Spacelab output processor	$ 100
Space and Ground Networks, Communication and Data Systems	Goddard Space Flight Center, Bldg. 14, 51-82-06	Command Management System	Provides computing capability for Project Operations Control Centers (POCC's)	$ 2,000
Space and Ground Networks, Communication and Data Systems	Goddard Space Flight Center, Bldg. 14, 51-82-07	Orbit Computation System	Provides mission operations orbit computing support	$ 800
Space and Ground Networks, Communication and Data Systems	Goddard Space Flight Center, Bldg. 23, 51-84-03	Gamma Ray Observatory (GRO) Data Capture System	Captures science data from the GRO spacecraft	$ 2,100

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Space and Ground Networks, Communication and Data Systems	Goddard Space Flight Center, Bldg. 3/14, 51-84-06	Univac 1100/82 leased system in the Network Control Center	Main Processor System supporting operational Network Control Center for TDRSS	$ 1,800
Space and Ground Networks, Communication and Data Systems	Goddard Space Flight Center, Bldg. 3/14, 51-87-01	Display and assurance segment computer hardware	Network Control Center Augmentation	$ 2,000
Space and Ground Networks, Communication and Data Systems	Goddard Space Flight Center, Wallops Flight Facility, 51-87-02	Tracking system replacements including surveillance radar precision mobile telemetry tracker and VHF/UHF communications equipment	Flight mission support	$ 3,000

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

FISCAL YEAR 1987 ESTIMATES

SUMMARY OF CONSULTING SERVICES ESTIMATES

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
	(Thousands of Dollars)			
Research and Program Management				
Consultants Employed by NASA..........................	450	500	500	500
Contractual Services................................	720	800	800	800
Subtotal...	1,170	1,300	1,300	1,300
Research and Development				
Contractual Services................................	2,677	2,900	2,900	2,900
Total, NASA..	3,847	4,200	4,200	4,200

NASA uses paid consultants and consulting services contracts to provide advice and expert input in addition to or beyond that available from its in-house, civil service workforce. Management controls are established which assure that before entering into either a consultant services arrangement with an individual or a consulting services contract, there is ample justification presented and the action is approved at top management levels. The use to which these services will be put is as follows:

Research and Program Management

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
Consultants Employed by NASA..........................	450	500	500	500

NASA hires experts and consultants for a variety of reasons, chiefly to provide expert advice and input on the selection of experiments for future space missions. The use of contract employees, in addition to NASA civil service personnel, provides the agency with an independent view that assures the selection of experiments likely to have the greatest scientific merit. Other individuals are employed to provide independent looks at technical and functional problems in order to give top management the widest possible range of views before making major decisions.

	1985 Actual	1986 Budget Estimate	1986 Current Estimate	1987 Budget Estimate
			(Thousands of Dollars)	
Consultant Services	720	800	800	800

NASA contracts with consulting services firms for studies of functional processes on a selected basis. In 1986 these studies are needed to provide independent assessment and expertise in such areas as ADP, EEO and utility rate validation.

Research and Development

Contractual Services	2,677	2,900	2,900	2,900

Future Program Evaluation	2,100

In consonance with its legislative charter, NASA seeks advice from many sources in the private sector on what would be the most productive future programs. The purpose for seeking such advice is to assure the widest review of that programmatic thrust is available. In addition, some funds are required to provide external expertise and input into organizational decisions, and evaluation of program effectiveness. In 1986, the largest portion of the funds will be used to support analyses conducted by the National Academy of Sciences in the Space Science and Applications, and Aeronautics and Space Technology program areas.

Studies of Future Operational Modes	450

These funds will provide for the contractual support of studies of future organizational structures to assure independent evaluation of the various options developed.

Other Consulting Studies	350

Funds will be provided for special studies in management areas. Studies in the area of management structure, and program evaluation and effectiveness are a valuable input to decision making. The specific studies are not defined in advance, but are approved based on demonstrated need.

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DETAIL OF PERMANENT POSITIONS

	1985 ACTUAL	1986 ESTIMATE	1987 ESTIMATE
EXECUTIVE LEVEL II	1	1	1
EXECUTIVE LEVEL III	1	1	1
EXECUTIVE LEVEL V	1	1	1
SUBTOTAL	3	3	3
ES-6	46	46	46
ES-5	123	123	123
ES-4	255	255	255
ES-3	63	63	63
ES-2	21	21	21
ES-1	12	12	12
SUBTOTAL	520	520	520
GS-18	0	0	0
GS-17	1	1	1
GS-16	4	4	4
GS/GM-15	1,655	1,644	1,644
GS/GM-14	2,909	2,895	2,896
GS/GM-13	5,010	4,971	4,993
GS-12	2,689	2,678	2,668
GS-11	2,055	2,017	1,989
GS-10	334	322	323
GS-9	1,112	1,086	1,093
GS-8	345	338	337
GS-7	1,008	1,075	1,119
GS-6	643	630	630
GS-5	1,217	1,179	1,179
GS-4	411	389	384
GS-3	133	130	127
GS-2	44	42	42
SUBTOTAL	19,570	19,399	19,429
SPEC UNGRADED POSITIONS ESTABLISHED BY NASA ADMIN	52	61	42
UNGRADED	1,253	1,217	1,206
TOTAL PERMANENT POSITIONS	21,398	21,200	21,200

PERSONNEL SUMMARY

	1985 ACTUAL	1986 ESTIMATE	1987 ESTIMATE
AVERAGE GS/GM GRADE	11.29	11.30	11.30
AVERAGE ES SALARY	$68,922	$69,000	$69,000
AVERAGE GS/GM SALARY	$38,434	$38,950	$39,200
AVERAGE SALARY, GRADES ESTABLISHED BY NASA ADMINISTRATOR	$28,504	$28,950	$29,200
AVERAGE SALARY OF UNGRADED POSITIONS	$61,752	$61,800	$61,800